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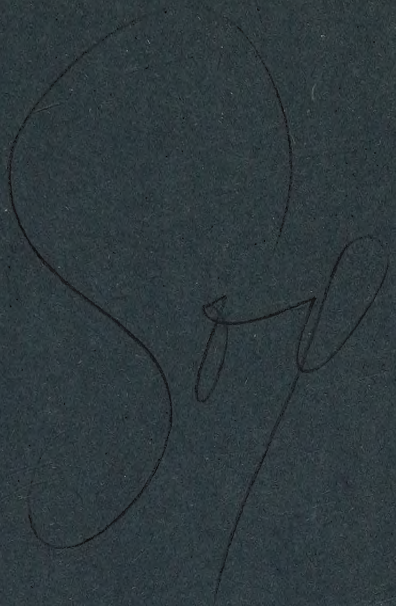

SURGICAL ANATOMY OF THE HUMAN BODY

DEAVER

GENERAL ARRANGEMENT OF CONTENTS

VOLUME I.—Scalp—Cranium—Brain—Face—Mouth—Throat—Organs of Special Senses.

VOLUME II.—Upper Extremities—Neck—Shoulders—Back—Lower Extremities.

VOLUME III.—Joints of the Lower Extremities—Chest—Thorax—Abdomen—Pelvis—Perineum.

SURGICAL ANATOMY OF THE HUMAN BODY

BY

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THOROUGHLY REVISED AND REARRANGED

PROFUSELY ILLUSTRATED WITH DRAWINGS FROM ORIGINAL DISSECTIONS MADE ESPECIALLY FOR THIS WORK

VOLUME II

UPPER EXTREMITIES, NECK, SHOULDERS, BACK, LOWER EXTREMITIES

PHILADELPHIA

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SURGICAL ANATOMY

UPPER EXTREMITY

SURFACE ANATOMY OF THE UPPER EXTREMITY

Divisions.—The upper extremity is divided into the shoulder, the arm, the forearm, the wrist, and the hand.

The **Articulations** are the scapulo-humeral and acromio-clavicular, or *shoulder;* the humero-ulnar and humero-radial, or *elbow;* the *proximal* and *distal radio-ulnar;* the *radio-carpal,* or *wrist;* the *intercarpal;* the *carpo-metacarpal;* the *intermetacarpal;* the *metacarpo-phalangeal,* of which there are five, and the *interphalangeal,* of which there are nine.

The various **movements** are important. The upper extremity, as a whole, can be rotated on its axis at the shoulder-joint, the freedom being such that any part of the body can be touched by one or the other hand. At the elbow the movements are flexion and extension; the former is limietd by the contact of the forearm with the arm, and the latter by the contact of the olecranon process of the ulna with the humerus. Through the radio-ulnar articulations the forearm is supinated and pronated, and extreme pronation and supination are permitted by rotation of the humerus. Through the radio-carpal articulation, or wrist, the hand is flexed and extended on the forearm. The metacarpo-phalangeal and interphalangeal articulations provide for the opening and closing of the fist and the spreading of the fingers.

If the forearm is supinated and extended, it will be noticed that a line drawn in the long axis of the arm will form at the elbow an obtuse angle with a line drawn in the long axis of the forearm. The opening of the angle is directed laterally. This is due to the obliquity of the trochlear surface of the distal end of the humerus. (Plate CXXV.) This difference in direction, which is about ten degrees, is known as the *ulnar deflection,* or the "carrying angle." It is of importance in the treatment of fractures at or near the elbow-joint. The strength of the arm and its adaptability to various functions depend to some extent upon the maintenance of this angle. With the forearm extended and midway between pronation and supination, the lines are practically parallel; while in extreme pronation, the lines form an obtuse angle, the opening of which is directed medially instead of laterally. (Plate CXXVI.)

Surface Markings.—Before commencing the dissection of the upper extremity the surface markings should be studied. The region of the shoulder is formed by the scapula, the clavicle, the proximal part of the humerus together with the surrounding and overlying structures. Through these structures the upper extremity is attached to the thorax. The **clavicle** is readily felt, even in the stoutest persons. It is convex forward at its medial two-thirds, and concave forward at its lateral one-third. The clavicle has a slight downward slope when the body is in the upright position and with the arm at the side; but it is a little raised when the body is in the supine position. Advantage is taken of these facts in the reduction and treatment of fractures and dislocations of the clavicle. Its articulation with the sternum is easily felt, but that with the acromion process of the scapula, forming the bony arch of the shoulder, is not so easily distinguished. This articulation must not be confounded with the roundness of the shoulder, which is occasioned by the greater tuberosity of the humerus and the superimposed deltoid muscle, the most prominent point of the shoulder-joint. The relation of these bony points is important in the diagnosis of dislocations of the head of the humerus, and for incisions for resection of the shoulder-joint. A "deltoid tubercle" is sometimes present at the lateral third of the clavicle, and must not be mistaken for an exostosis.

The **infraclavicular fossa** (**delto-pectoral triangle**).—This fossa, also known as Mohrenheim's fossa, is a depression immediately below the middle of the clavicle, and corresponds to the interval between the origins of the pectoralis major and deltoid muscles. At the medial margin of this space the first rib is palpable and the first part of the axillary artery passes through it. It is less evident in muscular persons than in those not so well developed.

The **coracoid process** does not give rise to any visible external prominence, except in very thin persons, but can be palpated by introducing the finger into the infraclavicular fossa (*delto-pectoral triangle*) and displacing the anterior border of the deltoid upward and lateralward. Under this process the head of the humerus can be felt in anterior subcoracoid dislocations of the humerus.

The **acromion process** and the spine of the scapula are subcutaneous and very prominent. The acromion may consist of one piece or of two separate pieces which have failed to unite with the spine of the scapula; so that there may be one or two epiphyses, which, if incompletely united with the rest of the bone, may be mistaken for fragments of a fractured acromion except that the epiphyses, if present, will be found on both sides, while a fracture is rarely bilateral. The angle formed by the apposition of the acromion process and the spine of the scapula is readily made out, and affords a convenient point from which to measure the comparative length of the arms. In taking these measurements, the lowest

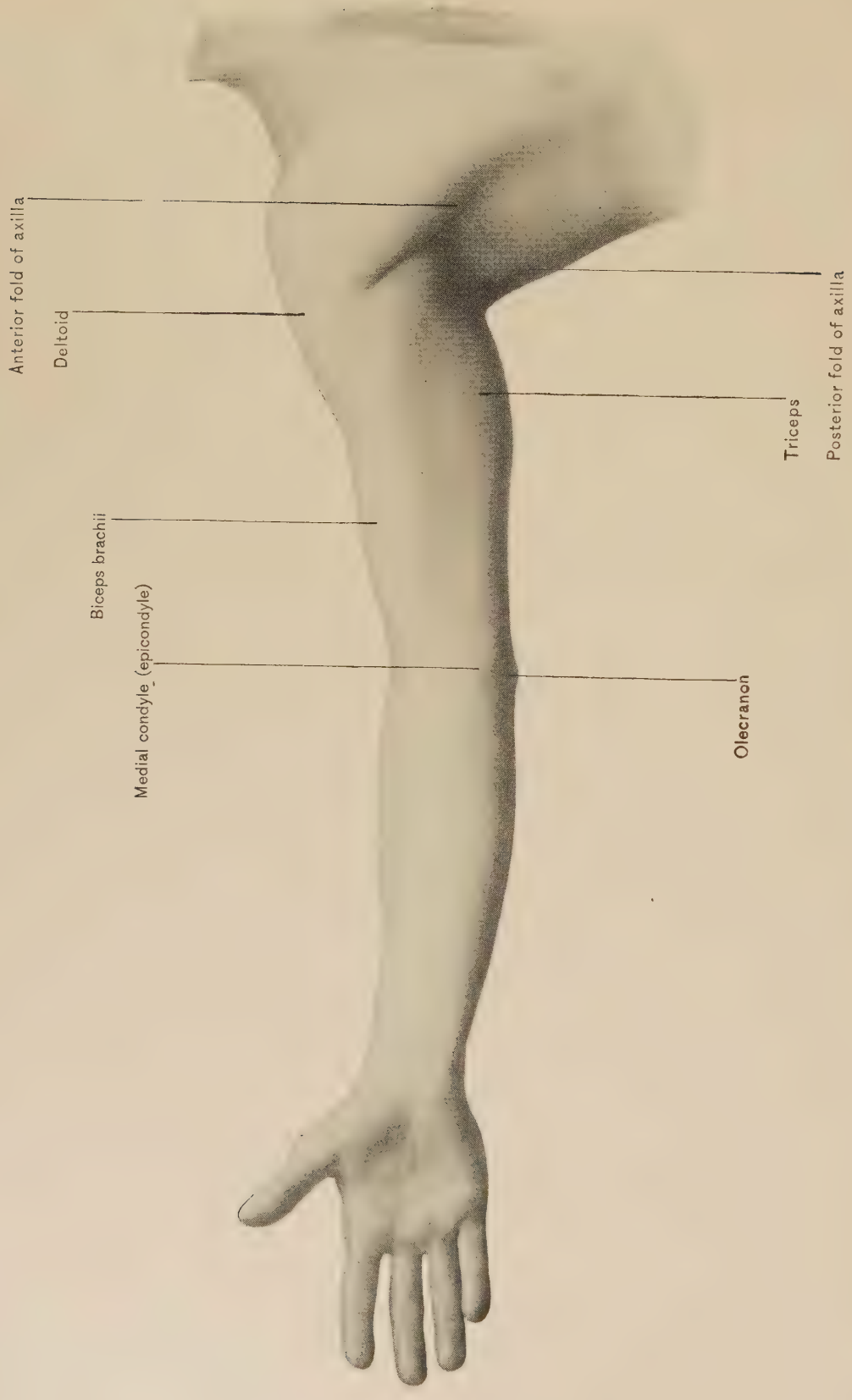
PLATE CXXV.

UPPER EXTREMITY—FOREARM SUPINATED, SHOWING CARRYING ANGLE.

PLATE CXXVI.

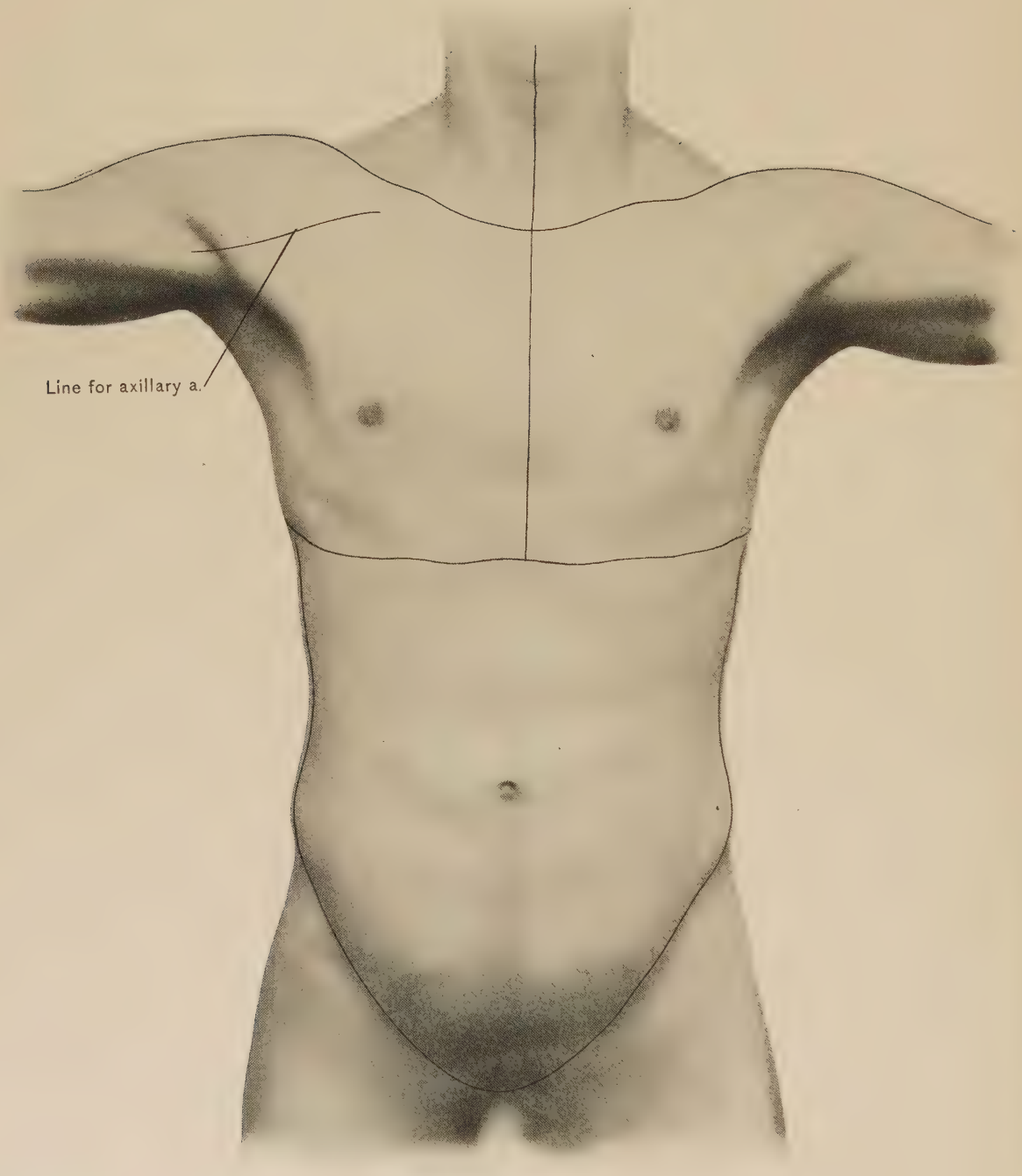
UPPER EXTREMITY—FOREARM PRONATED.

PLATE CXXVII.



UPPER EXTREMITY — LANDMARKS OF ANTERIOR (VOLAR) SURFACE.

PLATE CXXVIII.



LINES OF INCISIONS FOR DISSECTION AND LINE FOR AXILLARY ARTERY.

points selected are the lateral condyle (*epicondyle*) of the humerus and the tip of the styloid process of the radius. The two arms, needless to say, should be placed in the same position.

The **biceps brachii muscle** (Plate CXXVII) stands out as a well-rounded prominence on the anterior surface of the arm. It is limited on each side by a more or less well-marked groove, the medial and the lateral bicipital grooves, or sulci. The medial groove contains the principal vessels and nerves of the arm; the lateral, the cephalic vein.

The **deltoid muscle,** covering the greater tuberosity of the humerus, can be easily recognized. Paralysis and subsequent atrophy of this muscle will cause part of the roundness of the shoulder to disappear. Through this muscle the greater tuberosity of the humerus can be distinctly felt. The prominence immediately below the acromion, easily felt through the deltoid muscle, especially with the arm rotated on its long axis, is the greater tuberosity; to the medial side of, and a little below this the lesser tuberosity can be felt. The bicipital groove (*intertubercular sulcus*) which accommodates the long tendon of the biceps, can be felt by making pressure in a vertical line between these two prominences, the arm being rotated laterally and hanging at the side. In dislocation of this tendon, which, however, is quite rare, the groove is much more easily palpable.

The **head of the humerus** is most readily felt by inserting the fingers into the axilla. In subglenoid dislocation the head of the humerus will be prominent in the axilla.

The **coraco-acromial ligament** is distinctly felt under the anterior fibers of the deltoid. The midpoint of this ligament corresponds to the site of the bicipital groove (*intertubercular sulcus*) and the long tendon of the biceps brachii.

The **course of the axillary artery** (Plate CXXVIII), with the arm at a right angle to the body, is indicated by a line extending from a point slightly to the medial side of the middle of the clavicle to a point midway between the two humeral condyles.

The **axilla,** or armpit, is a pyramidal space bounded medially by the thorax, laterally by the arm, and anteriorly and posteriorly by prominent muscle folds. The lower margin of the anterior wall of the axilla (the lower border of the pectoralis major) follows the fifth rib. Normally, the **glands** of the axilla are not palpable. The skin of the floor of the axilla is covered by an elongated patch of hair and is closely connected with the superficial fascia. In the skin and superficial fascia of the floor of the axilla are modified sebaceous and sweat glands. The former frequently become infected. If not treated promptly, the infection may involve the axillary lymph glands. The lymph glands are frequently the site of metastasis of carcinoma of the breast, and very occasionally of primary malignant disease.

The **course of the vessels and nerves** of the arm, as in other parts of the body, is along protected routes. They pass from the axilla along the medial side of the arm, thence in front of the elbow and between the muscles of the proximal part of the forearm. In the distal third of the forearm they lie near the surface, between the flexor tendons, while in the hand they lie on the sides of the digits where they are more protected. The veins are more superficial, but injury of these is of less consequence than injury of either the arteries or the nerves.

The **deep and the superficial veins** communicate freely at the joints, thus insuring a free and uninterrupted return circulation during strong and continuous muscular contraction. The superficial veins are plainly visible in most individuals. The larger veins contain numerous valves, thus assisting in the return circulation.

The **course of the brachial artery,** with the arm at a right angle to the body, corresponds to that portion of a line which lies distal to the lower border of the teres major muscle, extending from a little to the medial side of the middle of the clavicle to the middle of the bend of the elbow. The artery is overlapped by the medial edge of the biceps muscle. It is readily reached in any part of its course, and is easily compressed at its middle, where it lies upon the insertion of the coraco-brachialis, opposite the insertion of the deltoid.

The **dimple behind the elbow,** so much admired in a well-rounded forearm, and very evident in children well supplied with fat, is the depression below the lateral humeral condyle (*epicondyle*). It indicates the position of the head of the radius, the rotation of which can be felt when the arm is alternately pronated and supinated. (Plate CXXIX.) **The bicipital tuberosity** (**tuberosity**) of the radius can be felt below the head of the radius on the back of the forearm while in extreme pronation, especially in thin persons.

The **supracondyloid process** is a hook-shaped spicule of bone which occasionally projects from above the medial condyle (*epicondyle*) of the humerus. It often gives origin to a third head of the pronator radii teres muscle, which covers the brachial artery. This process, which must not be mistaken for an exostosis, is the rudiment of a process of bone which forms the supracondyloid foramen in some of the mammalia. In these animals the foramen transmits the brachial artery and the median nerve.

Bursæ are present over the olecranon, the posterior proximal end of the ulna, and each condyle (*epicondyle*).

The **condyles** (**epicondyles**) **and the olecranon.**—The bony prominences at the elbow are important in the diagnosis of fractures and dislocations occurring in this locality. These prominences are the medial and lateral condyles (*medial* and *lateral epicondyles*) of the humerus and the olecranon process of the ulna. In their normal condition, with the forearm fully extended, the tip of the olecranon and the

PLATE CXXIX.

UPPER EXTREMITY—LANDMARKS OF POSTERIOR (DORSAL) SURFACE.

two condyles (*epicondyles*) lie in the same transverse line. With the forearm flexed, the olecranon process lies distal to a line drawn from one condyle (*epicondyle*) to the other. The vertical limits of the elbow-joint are indicated proximally, by an intercondyloid line; distally by the part of the head of the radius.

Extreme elbow flexion arrests the flow of blood in the brachial artery distal to this joint.

Posteriorly to each side of the olecranon is a depression, usually distinctly marked when the forearm is extended, which marks the points at which the cavity of the elbow joint may be most easily reached for aspiration.

THE FOREARM AND WRIST

The **ulna** is subcutaneous along its posterior border throughout its entire length. Irregularities of the posterior border of the shaft are very readily detected during supination.

The **radius** is so enveloped by muscle in its proximal half that, with the exception of its head, it is beyond reach; but in its distal part it is quite accessible, being even subcutaneous at its distal end. The distal end of the radius extends further downward and forward than that of the ulna.

The **course of the radial artery** corresponds to a line extending from the middle of the bend of the elbow to the medial side of the base of the styloid process of the radius. The artery is overlapped in its proximal half by the supinator longus (*brachio-radialis*) muscle. At its distal part it lies to the lateral side of the tendon of the flexor carpi radialis. To reach it at this part of its course the medial edge of this muscle must be displaced laterally.

The **ulnar artery** takes a curved course, which may be represented by two lines: the one for the proximal third of the artery being drawn from a point one centimeter (three-eighths of an inch) below the middle of the bend of the elbow to the ulnar border of the forearm at the junction of its proximal with its middle third; the line for the lower two-thirds of the artery being drawn from midway between the medial condyle (*epicondyle*) and the middle of the bend of the elbow to the radial side of the pisiform bone. Because of their superficial location and their occasional anomalies, the exact position of the arteries of the upper extremity should be ascertained by digital palpation before the skin is incised.

The front of the carpus reveals the following points: the tubercle of the scaphoid (*navicular*) below the styloid process of the radius and to the medial side of the thumb extensors; the trapezium (*multangulum majus*), a little below the tubercle of the scaphoid (*navicular*); the pisiform, just below the ulna on the palmar surface, at the base of the hypothenar eminence; the cuneiform (*triquetrum*), upon the ulnar side of the pisiform; several transverse furrows

in front of the wrist, the lowest of which marks the proximal edge of the anterior annular (*transverse carpal*) ligament and the line of the intercarpal joint; the tendons, when the wrist is flexed; the pulsation of the radial artery where it lies on the radial side of the flexor tendons (between the tendons of the supinator longus (*brachio-radialis*) and flexor carpi radialis); the tendon of the flexor carpi ulnaris, which overlaps the ulnar artery and masks its pulsation. The line connecting the styloid processes of the radius and ulna corresponds to the radio-carpal, or wrist-joint. When the wrist is flexed this corresponds to the proximal line at the wrist-joint. The line of the joint itself is in the form of an arc with its convexity proximal. Incisions into the front of the wrist for the evacuation of pus should be made upon the ulnar side of, and rather close to the flexor carpi radialis tendon, so as to avoid the radial artery laterally and the median nerve medially, which lies a little to the ulnar side of this tendon. Too deep an incision may enter the flexor sheath, or great carpal bursa.

The **pulse.**—The pulsation of the radial artery in front of the distal end of the radius, upon the radial side of the flexor carpi radialis tendon, is commonly known as the "pulse." Sometimes the superficial volar arises high up and descends with the radial, thus giving the impression of a double pulse (pulsus duplex). Sometimes the radial artery turns backward over the radius higher up than usual, in which case the pulse will not be in its normal position.

"The anatomic snuff-box" (Plate CXXX) is a designation given by the French to the space upon the radial side of the dorsum of the wrist. It is bounded proximally by the styloid process of the radius, distally by the base of the metacarpal bone of the thumb, upon the radial side by the tendons of the extensor ossis metacarpi pollicis (*abductor pollicis longus*) and extensor primi internodii pollicis (*extensor pollicis brevis*), and upon the ulnar side by the tendon of the extensor secundi internodii pollicis (*extensor pollicis longus*). Within this space are found: the superficial radial vein, the radial artery, as it dips forward into the first interosseous space to form the deep palmar (*deep volar*) arch, and the base of the first metacarpal bone. In this space the artery gives off the posterior carpal (*posterior dorsal*), the first dorsal interosseous, the dorsalis pollicis, and the dorsalis indicis arteries.

"Tenalgia crepitans" is the name given to a grating sensation present on the dorsum of the wrist in synovitis of the sheaths of the extensor tendons of the fingers.

THE HAND

The **palm** of the hand presents two eminences, the thenar, the ball of the thumb, and the hypothenar; one depression, and three furrows, two palmar and one arched. The *thenar eminence* is produced by the short muscles of the thumb,

PLATE CXXX.

Tendon of extensor primi internodii pollicis
(extensor pollicis brevis)
Tendon of extensor secundii internodii pollicis
(extensor pollicis longus)
Line of incision for radial a.
Tendon of extensor ossis metacarpi pollicis
(abductor pollicis longus)

INCISION FOR RADIAL ARTERY IN "SNUFF-BOX."

PLATE CXXXI.

PRINCIPAL FLEXOR FURROWS.

and is situated at the base of the thumb. The *hypothenar eminence* is produced by the short muscles of the little finger and is located at the base of that finger. The *depression* in the palm, or hollow of the hand, is triangular in shape, the base of the triangle being formed by the elevations at the roots of the fingers, its sides by the thenar and hypothenar eminences, and its apex by the junction of the thenar and hypothenar eminences.

The palmar (*volar*) flexor furrow (Plate CXXXI) is composed of two parts, an ulnar and a radial. The ulnar part (convex upward) extends from in front of the head of the fifth metacarpal bone to the web between the second and third fingers, and the radial part (convex downward), from in front of the head of the metacarpal bone of the second finger to the hypothenar eminence. When the fingers are flexed, the transverse portions of these furrows form a deep fissure with a central interruption. This fissure indicates the position of the heads of the metacarpal bones; the upper limits of the synovial sheaths of the flexor tendons of the second, third, and fourth fingers; the division of the palmar fascia (*palmar aponeurosis*) into four slips, and the transverse metacarpal ligament; while a little below it the digital arteries bifurcate into their terminal branches. An arched furrow also extends around the base of the thenar eminence from the lateral end of the radial portion of the palmar (*volar*) flexor furrow. It is placed opposite the carpo-metacarpal joint of the thumb; this relation is analogous to that of the other two furrows to the metacarpo-phalangeal joints. Considering the metacarpal bone of the thumb as the first phalanx, which it is from a developmental point of view, the analogy is more complete, all three furrows marking the position of the basal articulations of the primary phalanges.

On the palmar (*volar*) surface of the fingers there are three transverse furrows, the first being nearly midway between the metacarpo-phalangeal and the first interphalangeal articulations, while the other two locate the position of the interphalangeal joints.

With the thumb strongly abducted, a line drawn with its convexity downward from the web of the thumb transversely across the hand to the pisiform bone represents, for all practical purposes, the course of the superficial palmar (*superficial volar*) arch. The deep palmar (*deep volar*) arch is one centimeter (three-eighths of an inch) closer to the wrist than the superficial arch.

The **interosseous arteries,** dorsal and palmar, course in the interosseous spaces, therefore when opening an abscess on either the palmar (*volar*) or the dorsal surface of the hand the incision should be carried over the metacarpal bones rather than over the interspaces.

The **sesamoid bones of the thumb** lie just beyond the metacarpo-phalangeal joint, that is, to its distal side, so that in amputation through the joint the incision into the articulation should be made on the proximal side of these bones.

The **knuckles,** consisting of three rows, are formed by the distal ends of the proximal bones. Thus, the heads of the metacarpals form the first, the distal ends of the first phalanges the second, and the distal ends of the second phalanges the third row. To enter the knuckle of the metacarpo-phalangeal joint for amputation the knife should be carried a little in advance of the prominence of the knuckle.

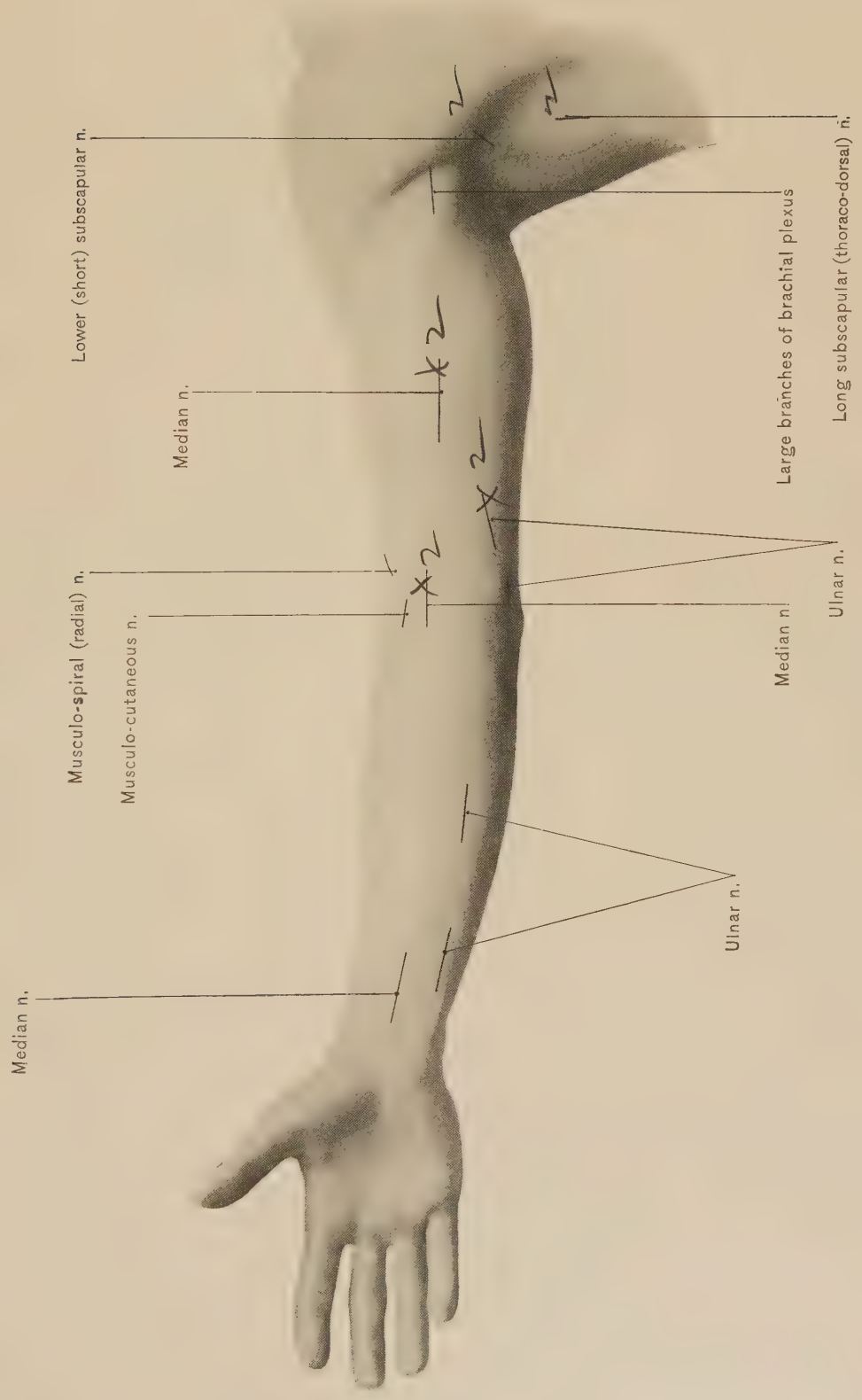
The **motor points** are found where the nerves become superficial by perforating the deep fascia, or where they emerge through or between muscles to take a superficial course. It is at these points that response is most readily secured to a concentrated electric current from a small electrode, causing marked tingling and decided muscular contraction with a strength of current that is scarcely, if at all, noticeable at other parts of the cutaneous surface. The points are well shown in Plates CXXXII; CXXXIII.

Measurements of the arm are made from the tip of the acromion, or the angle of junction of the acromion with the spine of the scapula, to the lateral condyle (*epicondyle*), and, with the forearm extended and supinated, from this to the top of the styloid process of the radius. Each point should be identified and marked with a dot of ink. The custom of identifying these points while measuring with a tape may cause errors of a centimeter (three-eighths of an inch) or more in two successive measurements by the same individual, an important item in medico-legal cases.

Dissection.—The dissection of the upper extremity includes as much of the front and back of the chest as is connected with the arm, together with the shoulder, axilla, arm, forearm, and hand. Preparatory to making the dissection, the cadaver should be placed upon its back, with the arm at a right angle to the body and resting upon a flat board, to which the hand should be fastened in supination. A block, ten to twelve centimeters (four to five inches) in thickness, should be placed under the shoulders. In order to preserve the parts they should be bandaged as high as the middle of the arm, and kept covered with oiled muslin, the covering being removed as the dissection progresses.

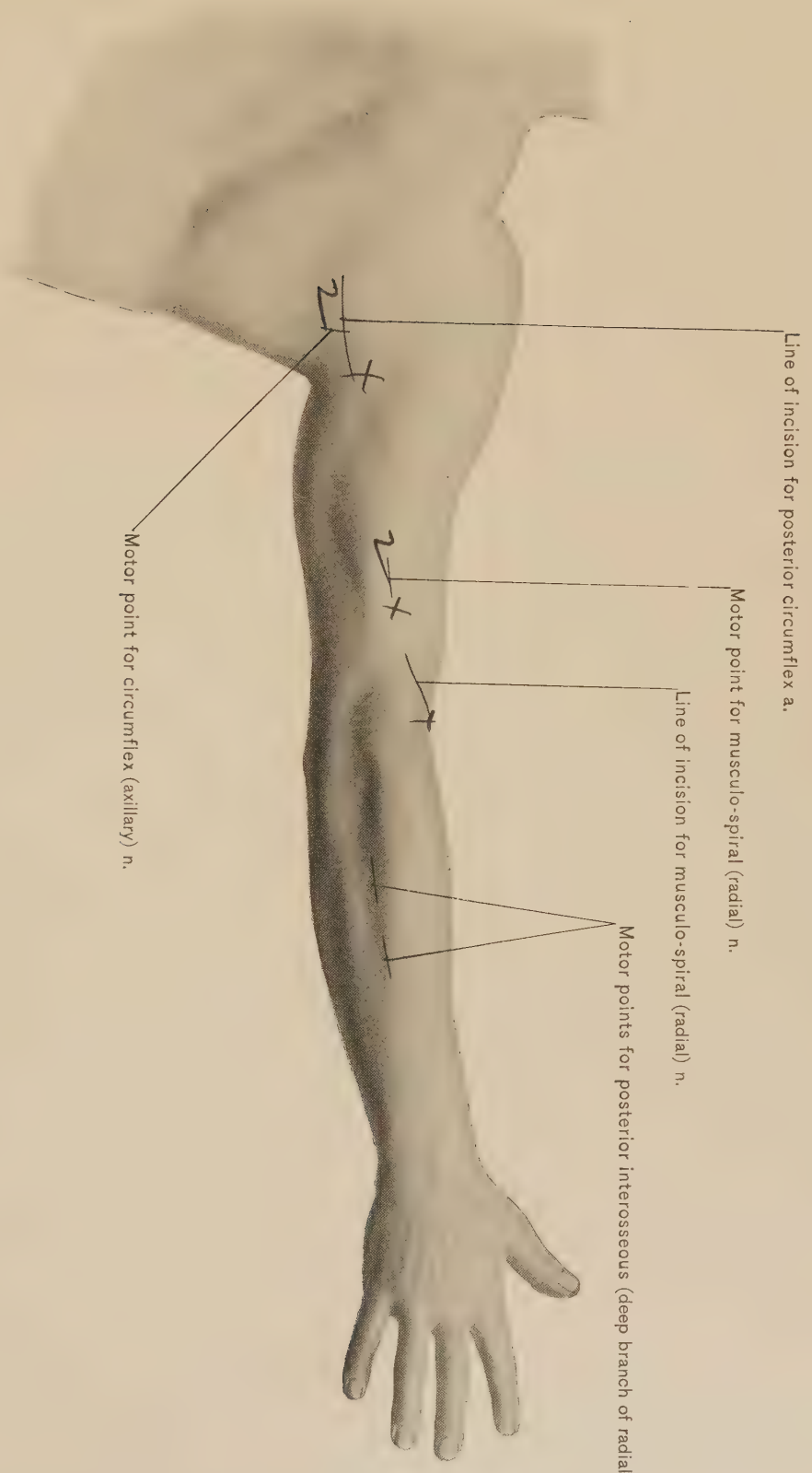
In reflecting the skin the flaps should be made as large as possible for two reasons: first, there is no better covering than the skin to preserve the moisture of the underlying structures; secondly, the dissector is thus enabled to review the surface anatomy of the part from time to time and carefully study the relations of the surface markings to the deeper structures. In removing the skin from the anterior chest only three incisions are necessary: one extending along the median line of the entire length of the sternum, another from the upper end of this incision along the clavicle to its acromial end and thence downward over the shoulder to the lateral side of the middle of the arm, and a third from the lower end of the sternal incision laterally to the line of the posterior fold of the axilla.

PLATE CXXXII.



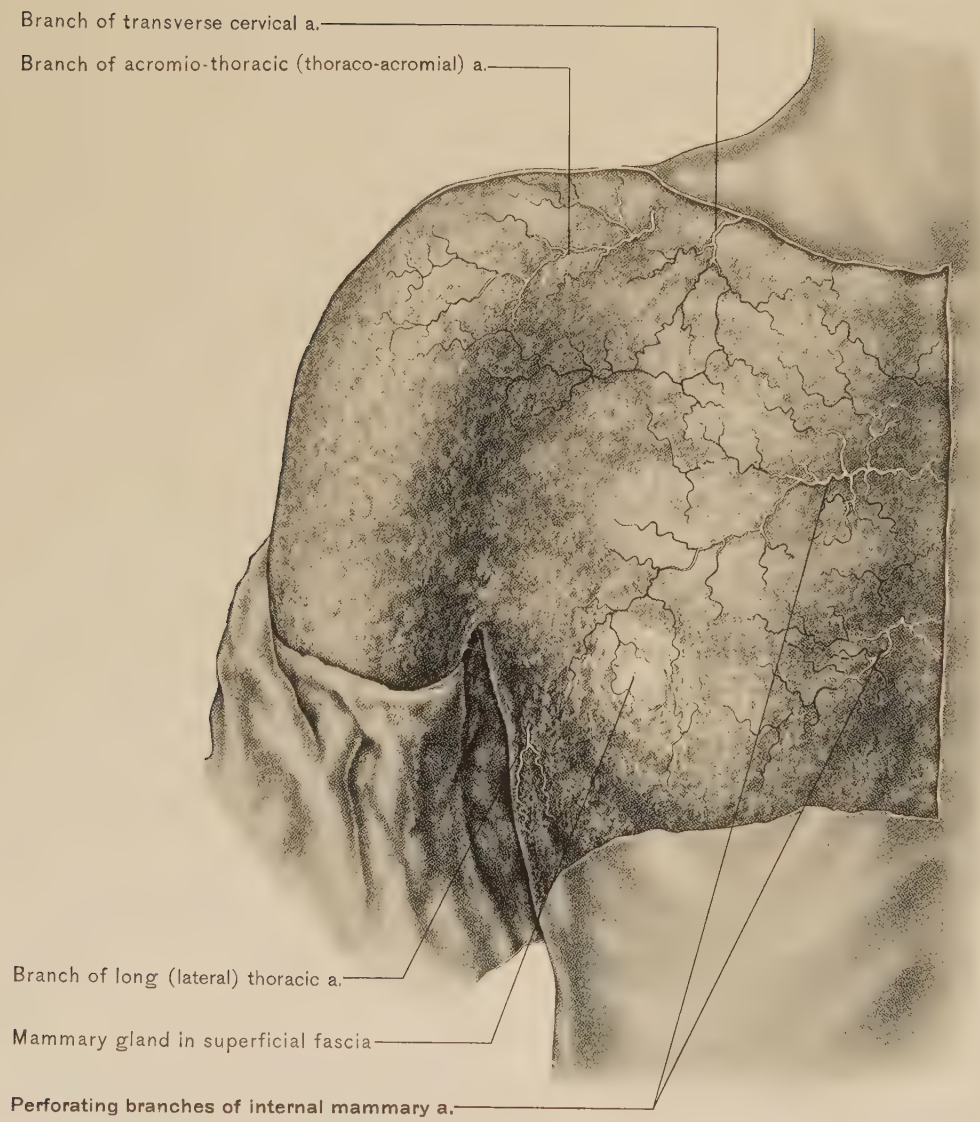
ANTERIOR VIEW OF UPPER EXTREMITY — MOTOR POINTS.

PLATE CXXXIII.


Line of incision for posterior circumflex a.
Motor point for musculo-spiral (radial) n.
Line of incision for musculo-spiral (radial) n.
Motor points for posterior interosseous (deep branch of radial) n.
Motor point for circumflex (axillary) n.

MOTOR POINTS AND LINES OF INCISIONS FOR POSTERIOR CIRCUMFLEX ARTERY AND MUSCULO-SPIRAL (RADIAL) NERVE.

PLATE CXXXIV.


Branch of transverse cervical a.
Branch of acromio-thoracic (thoraco-acromial) a.
Branch of long (lateral) thoracic a.
Mammary gland in superficial fascia
Perforating branches of internal mammary a.

SUPERFICIAL FASCIA OF PECTORAL REGION.

The skin only is then grasped at the superior sternal angle with a pair of forceps and is gradually reflected by severing its connection to the underlying fascia with a knife; but as soon as enough has been turned back to be readily grasped with the fingers, they should take the place of the forceps, thus ensuring easier, more rapid, and neater work. The superficial fascia and its nerves and vessels are now exposed, although in the infraclavicular and shoulder regions there will be seen a thin layer of muscle fibers passing over the clavicle into the neck. This is the origin, or inferior attachment, of the *platysma muscle*, a superficial structure by which the skin of the neck is moved. It is a remnant of a well-marked and useful structure, the *panniculus carnosus*, a thin layer of muscle fibers situated in the superficial fascia in lower animals, which enables them to shake off flies and other insects by rapid vibratory motions of the hide.

The skin over the sternum is thicker than over the lateral regions of the thorax and is closely connected with the superficial fascia. It is tense and not readily raised up in folds, and it retracts considerably when divided. In males it is often covered with a growth of hair associated with large sebaceous glands. Keloids are not uncommon in this location.

The **superficial fascia** (Plate CXXXIV) consists of a *superficial layer* of connective tissue, which contains only a small amount of adipose substance, and a *deep layer*, which is membranous and resembles the deep fascia to which it is attached. Between the two layers are found the mammary glands, the vessels, and the nerves. Numerous septa are sent in between the various lobes of the mammary gland from both layers of the superficial fascia. Over the sternum the adipose tissue is less abundant than elsewhere in the anterior thoracic region; in corpulent persons, therefore, the sternal area is relatively depressed.

The **vessels of the superficial fascia** are: five or six *perforating branches of the internal mammary artery*, which appear near the sternum and are directed laterally, the upper three usually going to the mammary gland and becoming enlarged in women during lactation, the lower two or three supplying the pectoralis major. The upper five or six *anterior intercostal branches* of the *internal mammary* also appear upon the anterior chest to supply the pectoral muscles and the mammary gland. Two or three small vessels, *thoracic branches of the acromiothoracic (thoraco-acromial) artery*, descend upon the chest at the middle of the clavicle to supply the pectoralis major and anastomose with the preceding. The *acromial branches* go to the shoulder and supply the deltoid; they anastomose on the shoulder with the suprascapular (*transverse scapular*) and posterior circumflex arteries. The *descending branches* pass down the delto-pectoral sulcus at the side of the cephalic vein. The *long thoracic (lateral thoracic) artery* sends branches to the mammary gland and the superficial fascia. All of these vessels supply the

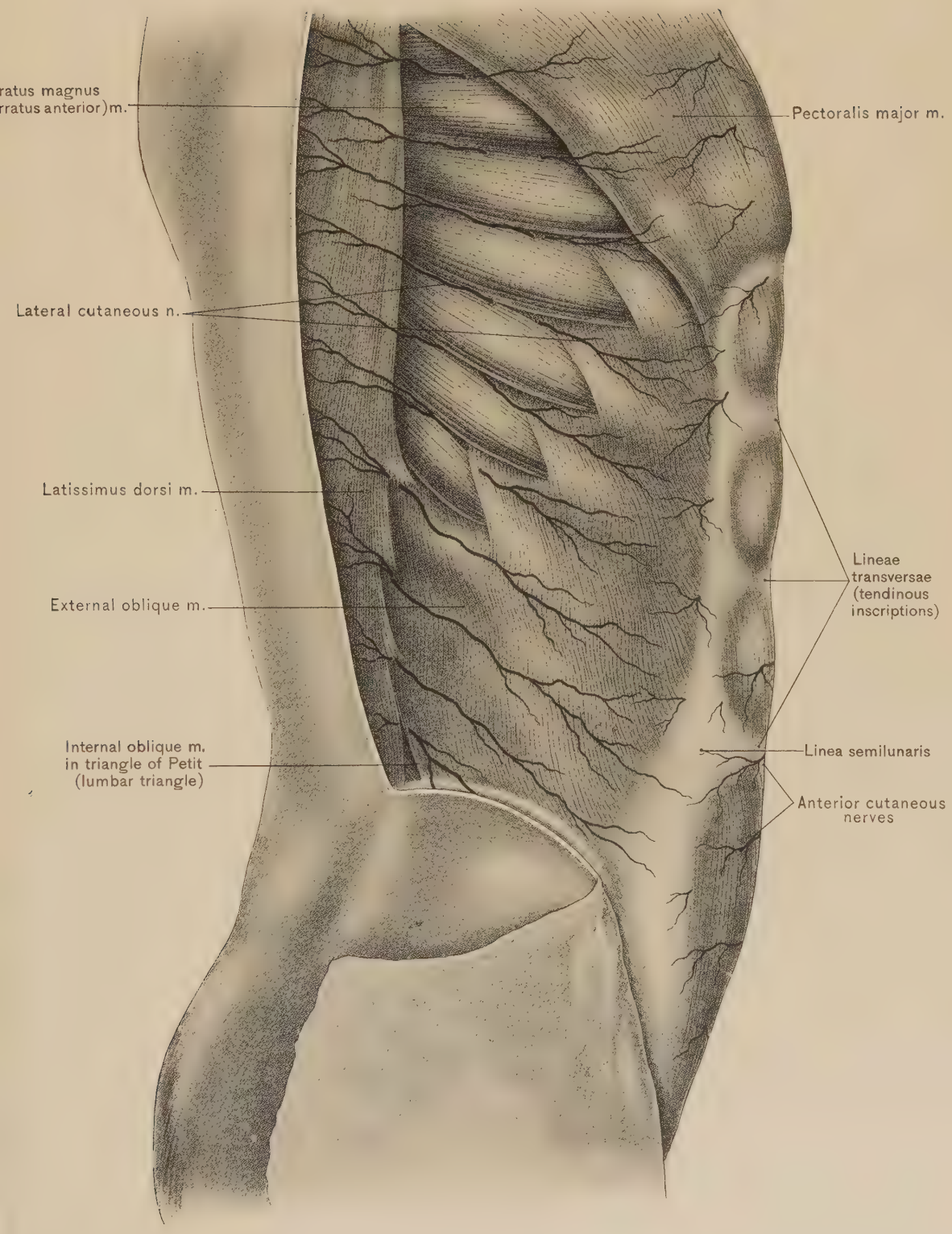
fascia and skin of this region, and are accompanied by veins and lymphatics, the latter becoming visible during acute inflammations.

The **nerves** in the fascia of this region are branches of the cervical plexus and the intercostals. From the *cervical plexus* come *inner*, or *suprasternal* (*anterior supraclavicular*), *branches*, which pass over the sternal end of the clavicle to the upper part of the sternal region of the chest; *supraclavicular* (*middle supraclavicular*) *branches*, to the infraclavicular region, and *supra-acromial* (*posterior supraclavicular*) *branches*, to the upper and posterior part of the shoulder. These three sets comprise the descending branches of this plexus. The *anterior cutaneous branches* of the upper six intercostal nerves pierce the pectoralis major to supply the skin and fascia over this muscle and the region of the sternum. A few twigs from the third and fourth go to the mammary gland. The *lateral cutaneous* nerves, branches of the intercostals, pierce the external intercostal muscles and emerge between the digitations of the serratus magnus (*serratus anterior*) muscle. They divide into anterior and posterior branches: the *anterior* passing upward over the lower border of the pectoralis major to the fascia and skin of the chest and to the mammary gland, and the *posterior* passing backward to the dorsum of the trunk, over the anterior margin of the latissimus dorsi. (Plate CXXXV.)

The **lymph vessels** of the anterior chest region, which are quite sparse, converge toward the axillary glands, and in their normal condition are as difficult to distinguish here as elsewhere.

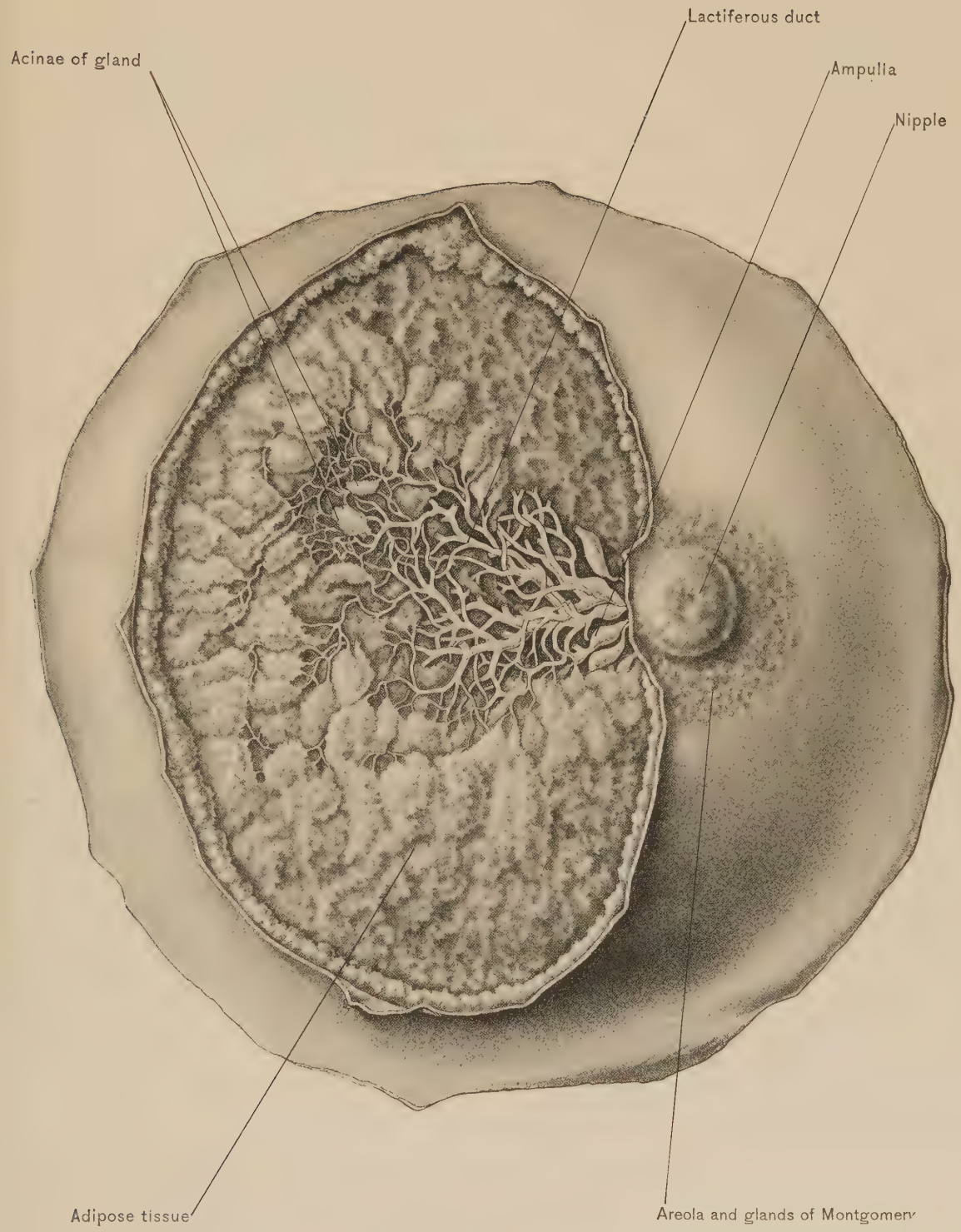
The **mammary glands** (Plate CXXXVI) are two smooth, rounded prominences forming the breasts of women. They are rudimentary in the male, although exceptional instances have been reported of men nursing children from their breasts. Morphologically considered, they are modified cutaneous glands. They are more or less hemispheroidal, the flat or concave base resting upon the deeper layer of the superficial fascia. The skin covering the glands is soft and very freely movable. The cutaneous veins are visible through it and may become very prominent during lactation. They are also more marked in mammary hypertrophy, abscess, or new growth. The glands extend from the third to the seventh rib and from the lateral border of the sternum to the anterior axillary border, the longest diameter extending upward and lateralward toward the axilla. The outline of the base of the gland is triangular, with two extensions, an upper toward the axilla, and a lower toward the sternum. The upper of these extensions may curve around the lower border of the pectoralis major muscle and come in contact with the serratus magnus (*serratus anterior*). Sometimes a completely detached portion of the gland or a supernumerary gland may lie in the axilla and form the starting-point of a tumor. The lower extension in large breasts may

PLATE CXXXV.



ANTERIOR CUTANEOUS AND LATERAL CUTANEOUS NERVES.

PLATE CXXXVI.



MAMMARY GLAND.

come in contact with the external oblique and the rectus abdominis muscles. Small portions of the gland may lie beneath the deep fascia, in or upon the pectoralis major, and the suspensory ligaments may contain glandular processes. All of these facts are of importance in the treatment of mammary carcinoma.

In the female the glands vary in size during life, being rudimentary in childhood, developing at puberty, and becoming more enlarged during pregnancy, to reach their highest development after childbirth and during lactation. They diminish after lactation, and thus alternately become larger and smaller during successive pregnancies, until the child-bearing and nursing periods have been passed, when they atrophy and again assume a rudimentary state.

The increase in size during pregnancy is due to the increase in adipose and connective tissue and to the development of lobules. These changes take place from the time of conception until lactation is established. After lactation and until the next pregnancy the mammary glands undergo atrophy. The ducts and acini are reduced in size and number and a number of indifferent cells are present from which new acini can be formed. During the atrophic process, however, the glandular secretion is sometimes unable to escape from certain acini. The result is engorgement followed by dilatation of the acini and possibly also hyperplasia of the lining cells. This process may be diffuse, causing the affected breast as a whole to feel shotty; or it may be localized, and palpation of the breast will suggest the presence of a tumor. Various names, such as chronic cystic mastitis, Schimmelbusch's disease, etc., have been given to this condition which of itself is benign, but is often difficult to differentiate by palpation, from a small carcinoma. The most descriptive term, I believe, is abnormal involution, since it indicates the probable origin of these small cystic structures.

Simple excision of the mass is the indicated procedure in the localized cases. The diffuse cases may subside under treatment, such as massage, strapping, or some other support. Otherwise surgery would be indicated.

The mamma is composed of glandular, fibrous, and fatty tissue. The *glandular structure* is racemose, and consists of small, secreting lobules, with confluent ducts, the lobules uniting to form lobes, each of which has a single main duct terminating in the nipple. There are from fifteen to twenty of these lactiferous, or galactophorous, ducts. They converge toward the nipple, and under the areola they form ampullæ, or dilatations, which serve as reservoirs for the milk; they again contract as they enter the nipple and open upon the summit by orifices smaller than the ducts themselves. The ducts are composed of connective tissue and longitudinal muscle fibers, and are lined with tessellated epithelium, continuous with the skin externally and with the glandular epithelium internally. The *fibrous structure* consists of the perimammary investiture of superficial fascia, the capsule of the gland, and its intramammary extensions,

which form supporting and connecting septa between the lobes of the gland. Some fibrous processes of the superficial fascia go to the nipple and skin, and are called suspensory ligaments (ligaments of Sir Astley Cooper). The *fatty tissue* covers the surface of the gland and its component lobes and consists of two portions, the perimammary and the interlobar; but it is not present within or immediately beneath the nipple. It is the amount of fatty tissue, rather than the glandular structure, that determines the size of the breast. The greater portion of the gland rests upon the sheath of the pectoralis major muscle, and the deep surface of the capsule of the gland is connected with the deep, or pectoral, fascia by loose connective tissue, in which a bursa sometimes exists. It is in this loose areolar tissue that submammary abscess occurs. This loose tissue allows for free movement of the breast on the pectoralis major, the breast moving somewhat with each contraction of the muscle. Therefore, in inflammation or after operation the upper extremity on the affected side should be put at rest. Sometimes this connective tissue is so loose in female savages, such as the Hottentots, that the glands can be thrown over the shoulder, and a child nursed while being carried upon the back. Surmounting the mammary gland is a conical elevation, the nipple.

The **nipple** is found over the fourth intercostal space, about twelve centimeters (four and three-quarters inches) from the median line, and is a pigmented, flattened, cylindrical elevation, composed of erectile tissue. It is covered with a modified integument which gives it a puckered appearance, and is provided with a few papillæ. On its summit are the openings of the lactiferous ducts. It is surrounded by a pigmented areola, which in virgins is a delicate rose color, becoming darker during pregnancy and, although later fading somewhat, never regaining its original color. It is composed of vessels mixed with unstriped circular and longitudinal muscle fibers, constituting the mammary muscles of the nipple and areola, to the action of which it owes its erectility. In the areola near the base of the nipple are found a small number of glandulæ sudoriforæ, also several rudimentary milk glands, tubercles, or glands, of Montgomery, which enlarge during pregnancy and in appearance suggest subcutaneous tubercles. They secrete a greasy substance which is intended to protect the nipples during lactation. The enlargement of these glands is one of the first signs of pregnancy. On the left side, especially in the male, the nipple serves as a guide to the location of the apex beat of the heart, which is usually about three centimeters (one and a quarter inches) below, and about one centimeter (three eighths of an inch) to its medial side. This position however is variable and cannot be relied upon as a definite measurement.

Infection in and around the nipple is a common occurrence, especially during lactation. This is due to the presence in the delicate skin of a number of sebaceous glands closely connected to the underlying structures and to the fre-

quent exposure to infection and irritation during nursing. Such infections may result in painful erosions, fissures or ulcers which are often intractable. Chronic inflammation of the nipple (eczema) is sometimes present in incipient malignant disease of the breast, such as Paget's disease, epithelioma, and carcinoma.

Blood Supply.—The mammary glands are supplied by branches of the axillary, the internal mammary, and the intercostal arteries. These vessels do not accompany the ducts. The axillary branches are: the long (*lateral*) thoracic, the short thoracic, and the pectoral branches of the acromio-thoracic (*thoraco-acromial*). The *long (lateral) thoracic artery*, although the largest vessel cut in radical excision of the breast, sends only a few twigs to the deep surface and some to the superficial surface of the superolateral quadrant of the breast. The long (*lateral*) thoracic is also known as the *deep external mammary artery*, in contradistinction to the *superficial external mammary artery*, or short thoracic, which is not constant, and which is a branch either of the third division of the axillary or the first portion of the brachial and reaches the gland by passing through the superficial fascia of the axilla. The *short thoracic*, when present, arises from the third portion of the axillary artery and crosses the axillary space in the superficial tissue where it anastomoses with the long (*lateral*) thoracic. The *pectoral branches* of the *acromio-thoracic* (*thoraco-acromial*) *artery* pierce the pectoralis major muscle and enter the deep surface of the breast. These anastomose with branches of the long (*lateral*) thoracic. The *upper three to five perforating branches* of the *internal mammary artery*, especially the second, third, and fourth, form the main arterial supply of the breast. They emerge from the intercostal spaces on each side of the sternum, pierce the pectoralis major muscle, and, turning laterally, ramify in the anterior layer of the superficial fascia, supplying the skin and more superficial parts of the breast. They send deeper branches to the parenchyma, which finally break up into a capillary network enclosing the alveoli. The *anterior intercostal branches* of the *internal mammary* and the *mammary branches* of the *intercostal arteries* run between the deep fascia and the deep layer of the superficial fascia, which they pierce to enter the deep surface of the breast. Subdivisions of these vessels form two plexuses, one on the superficial, and the other on the deep surface of the breast. Branches from the anterior plexus unite to form a secondary subareolar plexus from which branches are given off to the nipple, the areola, and the subjacent parenchyma, while the remaining branches of these plexuses form an anastomotic circle around the organ and send vessels to the parenchyma and to the stroma.

The deep *veins* accompany the arteries; the subcutaneous, or superficial, veins form an anastomosing circle around the base of the nipple, *circulus venosus of Haller*, from which large branches run to the periphery of the gland and thence to the external jugular, the axillary, and the internal mammary veins.

Nerve Supply.—The breast is supplied from the anterior and the lateral cutaneous branches of the fourth, fifth, and sixth intercostal nerves, the accompanying sympathetic fibers passing by way of the rami communicantes of the thoracic portion of the gangliated cord. These branches accompany the lactiferous ducts to end in the basement membrane surrounding the alveoli. The parenchyma being poorly supplied with sensory nerves explains the absence of pain in the early stages of tumor. The cutaneous nerves are from the anterior and lateral branches of the second to the fifth intercostals, the supraclavicular branches of the cervical plexus, and the lateral and medial anterior thoracic branches of the brachial plexus. The area of the nipple is rich in sensory nerves to which is due the exquisite pain associated with fissured nipple. In painful disease of the breast the pain is referred to the shoulder, neck, and back, and is due to involvement of the stroma. Pain referred downward along the arm in cancer of the breast usually denotes axillary involvement. It results from compression of the intercosto-humeral (*intercosto-brachial*) nerve. The third intercostal anastomoses with the second, and sends a branch to the arm and the dorsum of the scapula. These connections account for the diffusion of pain often noted in disease of the breast. No paralysis results from division of these nerves, but disturbance of them accounts for some of the pain and discomfort following operations in this region.

The **lymph channels** are exceptionally numerous and are of great surgical importance on account of the conspicuous rôle they play in inflammatory and, more especially, in neoplastic processes. The parenchymal lymphatics arise in the deeper portions of the mammary tissue from sac-like enlargements situated in the interlobular connective tissue. The majority pass to the surface and communicate with the delicate subareolar and subcutaneous plexuses of the anterior chest wall. From the breast the mammary lymphatics extend to the lymph nodes in the axilla on both sides, to the subscapular, the retrosternal, the retropectoral, the subclavicular, the supraclavicular, the paramammary, the diaphragmatic, the supraxyphoid (of Sappey), the upper brachial, the intercostal, and the inguinal groups of lymph nodes. Most of the lymph vessels coming from the deep part of the breast go to the axilla, although a few enter the mediastinal lymphatics following the internal mammary artery. In infections or malignant disease of the breast enlarged axillary lymph nodes may serve as obstacles to complete lymph drainage. In these cases accessory or collateral paths may be formed, since the subareolar plexus is a part of the general anterior thoracic net-work. The latter communicates across the median line, so that an affection of one gland may lead to involvement of the nodes along the lymph vessels of the opposite side. The subcutaneous network also communicates with the same network of the abdomen in the external oblique and rectus sheaths,

which allows for intra-abdominal or inguinal involvement, the intra-abdominal invasion resulting from the communication of the lymphatics around the umbilicus with those of the round ligament of the liver. Dissemination of carcinoma takes place principally by way of the lymphatics contained in the deep fascia of the breast into which all the efferent lymphatics of the adipose tissue in the breast, of the nipple, the areola, and the skin over it, open either directly or indirectly. To reach the axillary vessels, the lymph from the deep portion of the breast enters the lymph vessels in the deep fascia, or those lying deep in the fascia of the pectoralis major muscle, which vessels for the most part end in the glands along the anterior fold of the axilla, so that these lymph nodes are the first to be involved in metastasis from cancer of the breast, the axillary nodes being the next affected. The first gland to be involved in carcinoma of the breast usually is the one situated just beneath the border of the pectoralis major muscle upon the serratus magnus (*serratus anterior*) muscle at the third rib. Owing to these anatomic relations and the free intercommunication between the submammary and intramammary lymphatics, the operation for cancer of the breast which promises the best results is the one which removes the entire gland, including the skin of the diseased area, with total excision of the submammary and paramammary connective tissue, together with removal of the pectoral fascia, the pectoralis major muscle, the pectoralis minor muscle, the lymphatics and connective tissue of the axilla, the deep infraclavicular and the subclavian triangles. In other words, all the tissue between the primary focus of disease and the terminal lymph nodes should be looked upon as part of the original tumor and, as far as possible, should be removed. Handley has pointed out that lymphatic spread occurs along the fascial planes, and considers it of the utmost importance to practice wide fascial excision.

Should the axillary vein be accidentally wounded in the operation for removal of the breast, a small opening may be closed by pinching up the torn place and applying a lateral ligature; but if a large wound ensues, the vein must be tied at each side of the rent. Should the axillary vein be included in malignant tissue, ligatures should be applied above and below the involved portion and the latter excised.

In order to detect adhesions between the mammary gland and the pectoralis major muscle, as in carcinoma of the breast, the gland should be moved in the direction of the fibers of the muscle; moving the gland in the opposite direction may cause the relaxed muscle to move with the gland, so that no impairment of mobility will be noticeable. In palpating for tumors of the breast it is better to use the flat of the hand, since the normal lobes, especially if somewhat enlarged and cystic, may be mistaken for tumors by finger palpation.

The connection between the superficial fascia and the skin through the sus-

pensory ligaments explains the frequency with which mammary cancer extends to the cutaneous tissues. Shortening of the suspensory ligaments causes the so-called pig-skin, or orange skin, seen in late mammary cancer.

Congenital variations and anomalies of the breast.—The nipple may fail to develop properly and appear retracted; or it may be entirely absent, *athelia;* or supernumerary nipples, *polythelia,* may develop.

The breasts also may fail to develop normally and remain rudimentary and small, *micromazia.* Congenital absence of one or both breasts, *amazia,* may occur, but is rare; supernumerary mammæ, *polymastia,* or *polymazia,* have been observed in various parts of the body, such as the axilla, the anterior thoracic wall, the groin, the back, the thigh. Unusually large breasts in the male, *gynecomastia,* as well as the other anomalies mentioned are often associated with malformations of the genitalia.

In infants, shortly after birth, the breasts sometimes increase in size and secrete a turbid fluid. Occasionally it happens that in girls at the age of puberty the mammæ develop unequally, one rapidly increasing in size, while the other for a time remains retarded in growth. In boys also at puberty, the glands may become slightly enlarged and somewhat painful.

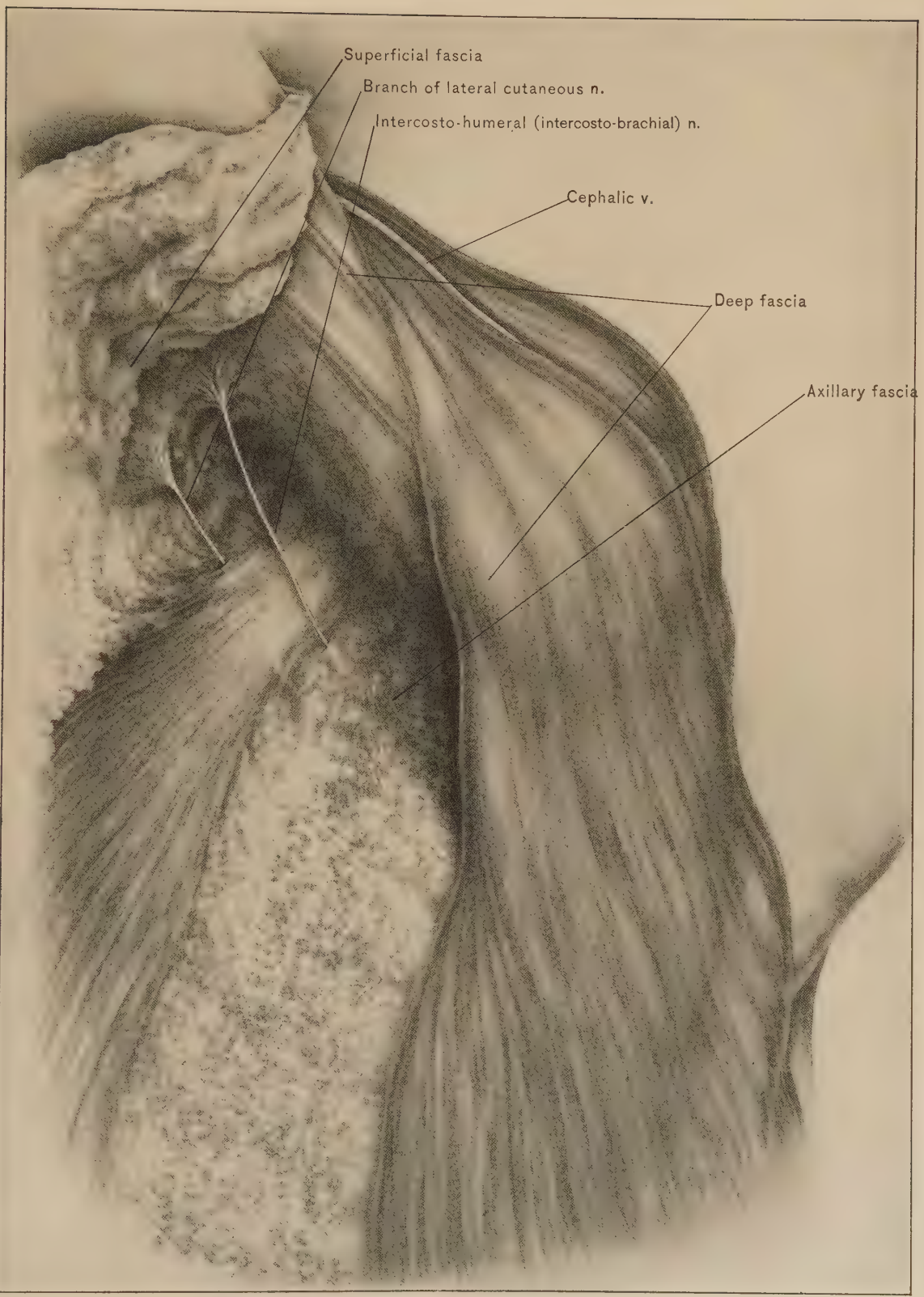
Dissection.—The deep fascia is exposed by removal of the superficial fascia, which should be dissected off in the same manner as the skin.

The **deep,** or **pectoral, fascia** (Plates CXXXVII; CXXXVIII) is continuous with that of the neck, shoulder, arm, back, and abdomen. It consists of a superficial and a deep layer. The superficial layer is attached to the anterior surface of the clavicle and the sternum, and blends below with the deep fascia of the external oblique muscle. It forms the sheath of the pectoralis major muscle. The deep layer lies beneath the pectoralis major, so that it cannot be studied until that muscle has been removed.

Dissection.—The superficial layer of the deep fascia should now be reflected and removed by cutting at right angles to the line of the muscle fibers. Its connection with the deep layer along the lower border of the pectoralis major should not be severed until the axillary fascia and its mode of formation have been demonstrated, as this is the point where the two layers blend to form that fascia.

The **pectoralis major** (Plate CXXXIX) is a large, thick, flat, fan-shaped muscle covering the front of the chest and the axilla; its base rests upon the sternum and the medial half of the clavicle, and its apex lies between the biceps and deltoid muscles in the upper part of the arm. It is divided by a slight separation of its fibers into an upper, or clavicular, a lower, or chondro-sternal, and an abdominal portion. The *clavicular portion* lies in front of the costo-coracoid membrane and the structures that pierce the membrane. It *arises* from the anterior surface of the sternal half or two-thirds of the clavicle and from the

PLATE CXXXVII.



DEEP, OR PECTORAL, FASCIA AND AXILLARY FASCIA.

PLATE CXXXVIII.

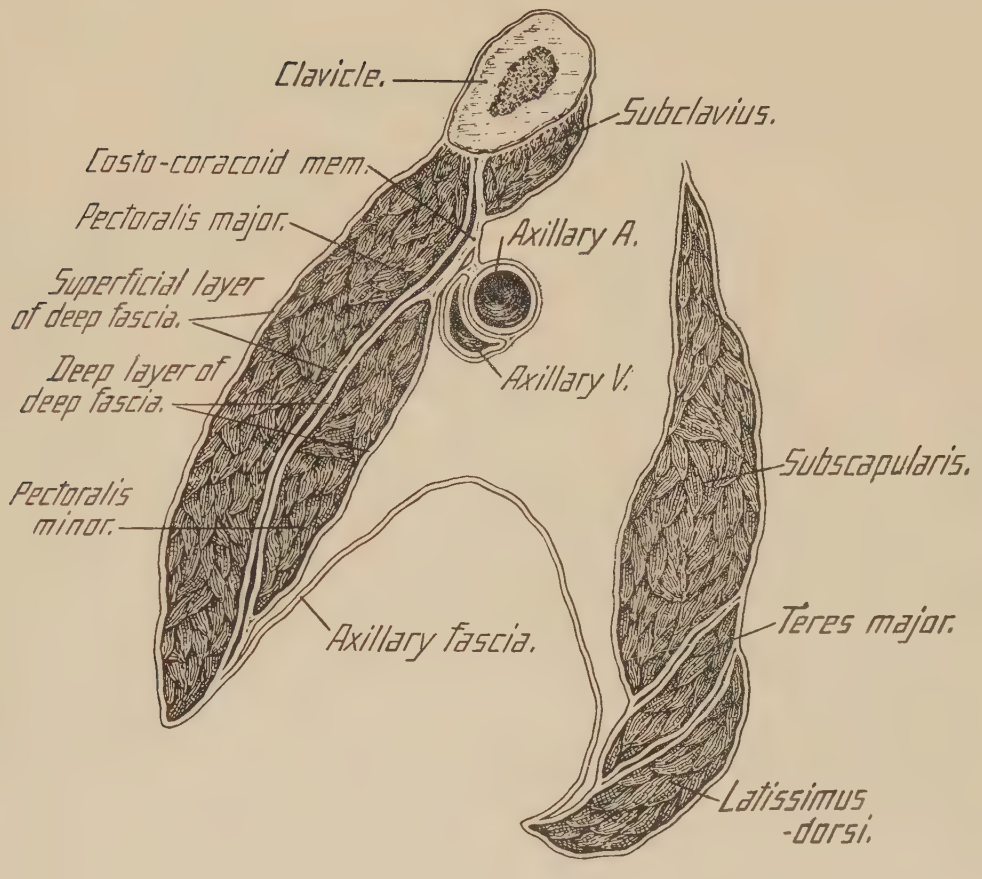
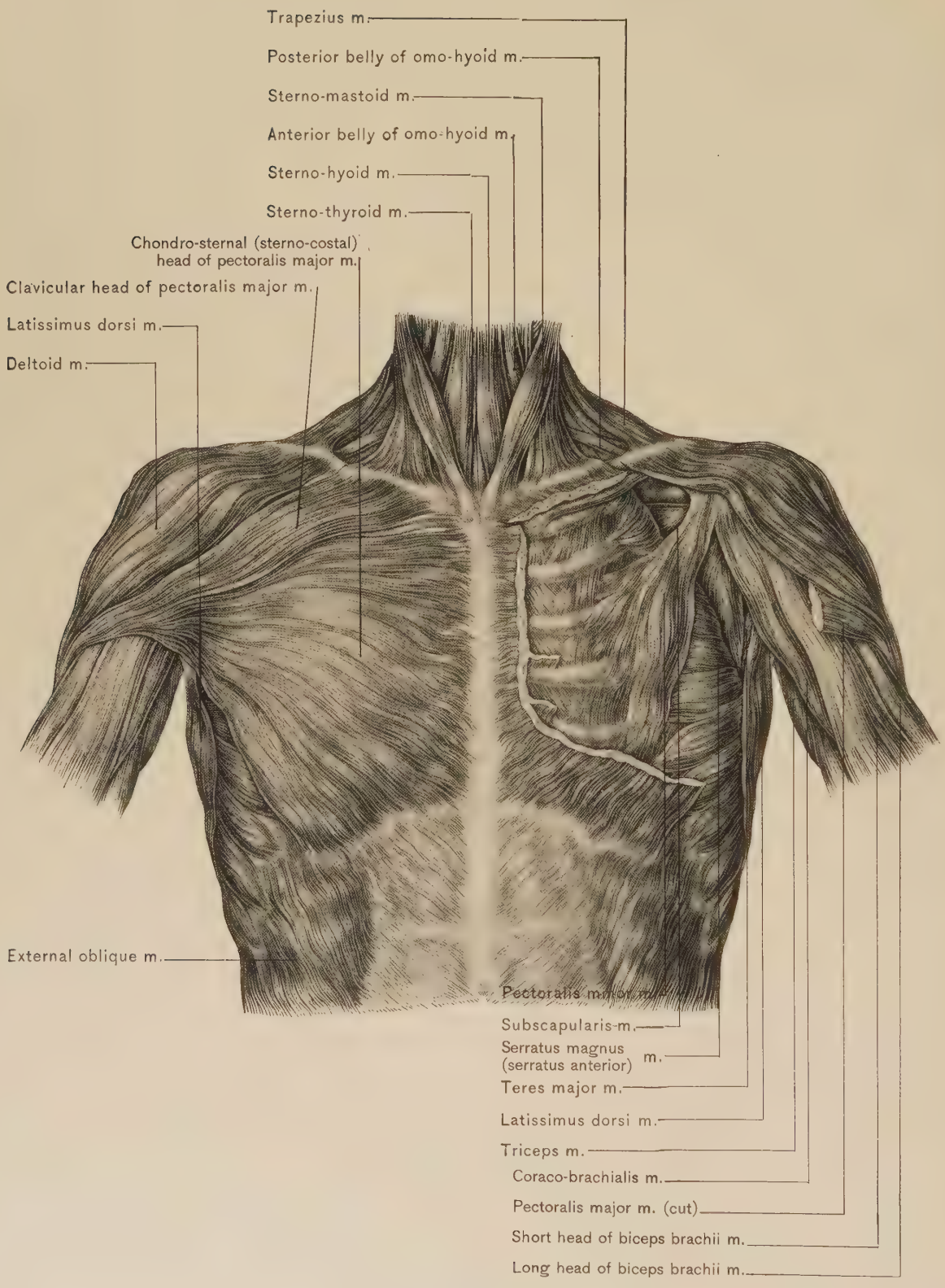


Diagram showing line of section.

DIAGRAM OF PECTORAL FASCIA AND AXILLARY FASCIA.

PLATE CXXXIX.



PECTORALIS MAJOR MUSCLE AND PECTORALIS MINOR MUSCLE.

adjacent portion of the sterno-clavicular articulation; its lateral fibers are in contact with the anterior margin of the deltoid. The *chondro-sternal portion*, which is the larger part of the muscle, lies upon the sternum, the ribs and the costal cartilages, the intercostal muscles, the pectoralis minor, part of the serratus magnus (*serratus anterior*), and the deep layer of the deep fascia. It *arises* from the lateral half of the entire length of the anterior surface of the sternum, except below the attachment of the seventh costal cartilage; from the cartilages of the true ribs, except in some instances either the first or the seventh, or both these ribs; from the sternal end of the sixth rib, and from the aponeurosis of the adjacent portion of the external oblique. From this extensive origin the fibers converge upon the front of the arm, forming a flat tendon about five centimeters (two inches) in length, which is *inserted* into the anterior bicipital ridge of the humerus, extending proximally to the greater tubercle of the humerus, blending laterally with the insertion of the deltoid and medially with the insertion of the latissimus dorsi. The lowest fibers of origin of this portion have the highest insertion on the ridge, while the upper fibers have the lowest insertion. Thus, the lower fibers are overlapped near their insertion by the middle fibers, and these in turn by the upper ones. The clavicular fibers pass downward and lateralward, the central ones horizontally lateralward, and the lower ones upward and lateralward. The anterior layer of this double tendon of insertion is thicker than the posterior layer and receives the fibers of the clavicular and the upper chondro-sternal portions, while the posterior portion receives the remaining fibers from the lower half of the muscle. The tendon of insertion sends one prolongation upward over the bicipital groove (*intertubercular sulcus*) to the greater tuberosity, thus binding down the long head of the biceps, and another backward to line the groove, and still another to the deep fascia of the arm.

The cellular interval between the chondro-sternal and clavicular portions of the muscle is represented by a depression on the chest when the arm is strongly abducted, and with the arm at a right angle to the body corresponds to a line drawn from the sterno-clavicular joint to the middle of the bend of the elbow. An incision through this interval exposes the first portion of the axillary artery.

Between the clavicular portion of the pectoralis major and the anterior edge of the deltoid is the *delto-pectoral*, or *infraclavicular*, *triangle*, which accommodates the cephalic vein and the descending, or humeral, branch of the acromio-thoracic (*thoraco-acromial*) artery. Medially, in some muscular individuals, the fibers of the pectoralis major decussate with those of its fellow of the opposite side. Occasionally, muscle fibers are found along the sternum, from the manubrium above to the sheath of the rectus below, and form the *rectus sternalis muscle*. The pectoralis major, pectoralis minor, and the deep layer of the deep fascia form

the anterior axillary wall. The lower edge of the pectoralis major forms the anterior axillary margin and, with the latissimus dorsi, converges toward the lateral part of the space.

Blood Supply.—From branches of the axillary artery, especially its acromio-thoracic (*thoraco-acromial*) and long thoracic (*lateral thoracic*) *branches* which ramify in the anterior pectoral region and from the internal mammary arteries.

Nerve Supply.—From the lateral and medial anterior thoracic.

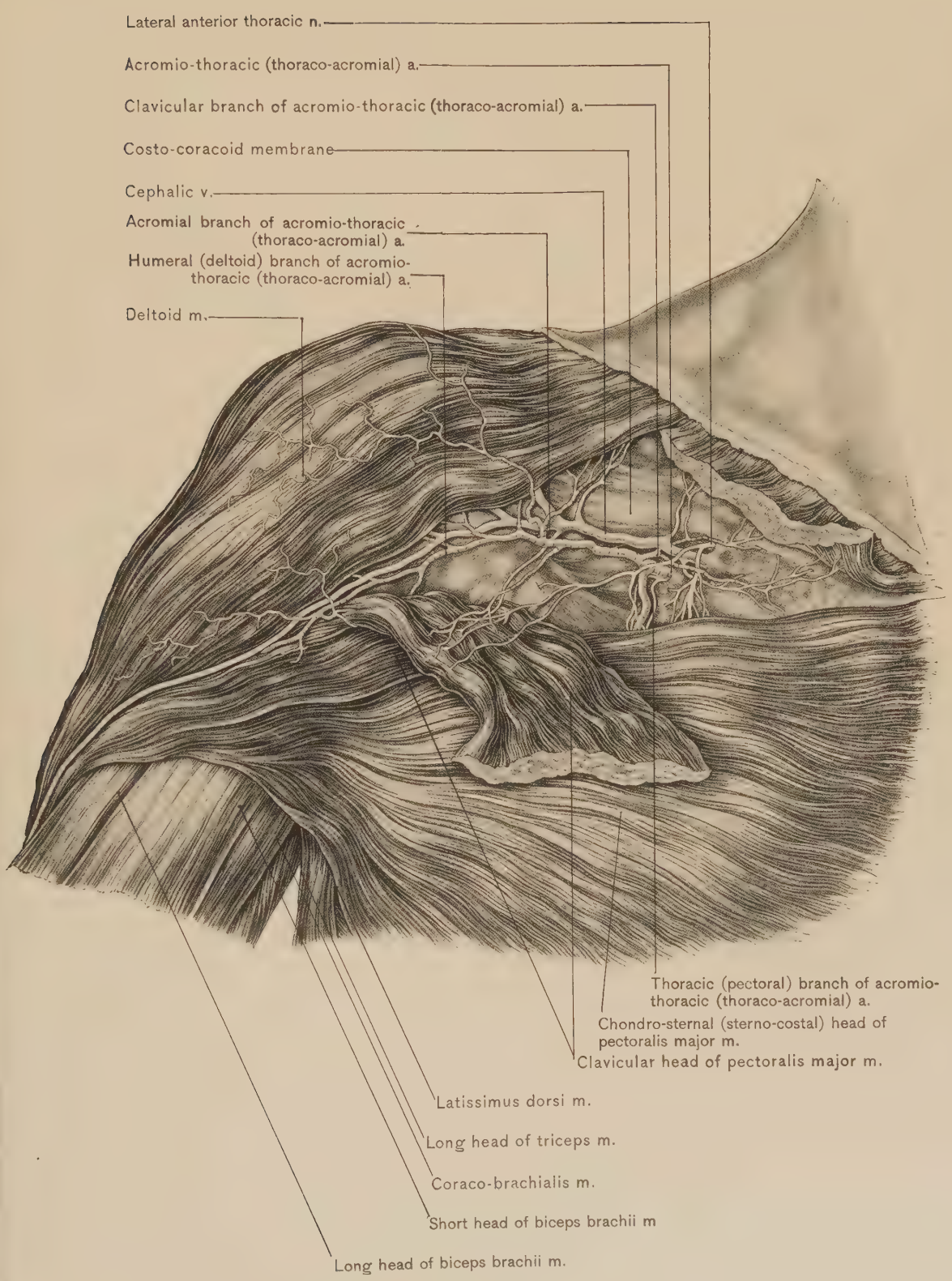
Action.—The action of the pectoralis major is complex. Its general function is to draw the elbow across the chest in anterior adduction. It is also a medial rotator of the humerus. The clavicular portion aids the anterior fibers of the deltoid in elevating the arm and drawing it forward, flexing the shoulder-joint, while the lowermost fibers of the chondro-sternal portion draw the arm downward and forward. The pectoralis major is a hugging muscle. With the arm fixed, its action is reversed; it then helps to elevate the body suspended by the arms, elevates the body in dipping between parallel bars, and is a powerful aid in difficult respiration. The pectoralis major is often the seat of carcinomatous deposits in malignant disease of the breast. In a radical operation for mammary cancer the muscle is always removed. The loss is compensated by subsequent hypertrophy of the anterior part of the deltoid muscle.

Dissection.—The next step in the dissection is to detach the clavicular portion of the pectoralis major from the clavicle and displace it downward and lateralward. This will expose a triangular-shaped space, the floor of which is formed by the deep pectoral, or clavi-pectoral, fascia. This space is the *superficial infraclavicular triangle*, in contradistinction to a still deeper one, the *deep infraclavicular triangle*, seen after the removal of the clavi-pectoral fascia.

The **superficial infraclavicular triangle** (Plate CXL) is bounded above by the medial half of the clavicle, and below by the upper edge of the sternal portion of the pectoralis major. The base is directed lateralward and is formed by the anterior border of the deltoid muscle; the apex, directed medialward, lies at the junction of the clavicle with the sternum. The contents of the triangle are fat and the structures which pierce its floor: the *cephalic vein*, the *acromio-thoracic (thoraco-acromial) artery* and *vein*, and the *lateral anterior thoracic nerve*.

The **deep pectoral, or clavi-pectoral, fascia** is attached above to the lips of the subclavian groove on the inferior surface of the clavicle. At its attachment to the clavicle it consists of two layers which inclose the subclavius muscle and unite along the lower border of that muscle to form a single layer. Laterally, it is attached to the upper surface of the coracoid process, and is denser here than medially where it blends with the intercostal fascia covering the upper two intercostal spaces. Below, it divides along the upper border of the pectoralis

PLATE CXL.


Lateral anterior thoracic n.
Acromio-thoracic (thoraco-acromial) a.
Clavicular branch of acromio-thoracic (thoraco-acromial) a.
Costo-coracoid membrane
Cephalic v.
Acromial branch of acromio-thoracic (thoraco-acromial) a.
Humeral (deltoid) branch of acromio-thoracic (thoraco-acromial) a.
Deltoid m.
Thoracic (pectoral) branch of acromio-thoracic (thoraco-acromial) a.
Chondro-sternal (sterno-costal) head of pectoralis major m.
Clavicular head of pectoralis major m.
Latissimus dorsi m.
Long head of triceps m.
Coraco-brachialis m.
Short head of biceps brachii m
Long head of biceps brachii m.

SUPERFICIAL INFRACLAVICULAR TRIANGLE.

minor to invest this muscle. From the lower border of the pectoralis minor it descends as a single layer to join the superficial layer of the deep, or pectoral, fascia along the lower margin of the pectoralis major, forming the *axillary fascia*. The deep pectoral fascia is sometimes spoken of as the *suspensory ligament of the axilla*, since by its connection with the fascial sheath of the pectoralis minor it suspends the axillary fascia (floor of axilla), thus forming the hollow of the arm-pit.

The **costo-coracoid membrane** is that portion of the deep pectoral fascia which fills the interval between the clavicle and upper border of the pectoralis minor muscle. The part of the membrane extending from the first costal cartilage to the coracoid process is thickened and forms the *costo-coracoid ligament*. It is denser than the lower part of the deep pectoral fascia, and is pierced by the *cephalic vein*, *the acromio-thoracic* (*thoraco-acromial*) *artery and vein*, the *lateral anterior thoracic nerve*, and sometimes by a branch of the *superior thoracic* (*thoracalis suprema*) *artery*. By its deep surface it is connected to the sheath of the axillary vessels. The fibers of the membrane run mediolaterally, and are put on a stretch when the arm is abducted. Advantage can be taken of this fact when ligating the first portion of the axillary artery.

Considerable importance attaches to the arrangement of the deep pectoral fascia because of possible purulent collections in this region. Such a collection situated behind the pectoralis major, or between it and the pectoralis minor, would point either at the anterior border of the axilla or under the clavicle in the upper end of the delto-pectoral triangle. If, however, the pus forms behind the pectoralis minor muscle and the deep layer of the deep fascia, it would either remain confined within the axillary space and point at the floor of the arm-pit or it would extend upward into the neck in the direction of least resistance and point above the clavicle.

Dissection.—Divide the anterior layer of the deep pectoral fascia along its attachment to the anterior lip of the subclavian groove of the clavicle and reflect it downward. This will expose the subclavius muscle.

The **subclavius** is a small, spindle-shaped muscle lying under the clavicle over the first rib. It *arises* by a short, thick tendon from the first costal cartilage in front of the costo-clavicular, or rhomboid, ligament, and the sternal end of the first rib, whence its fibers pass lateralward and upward, to be *inserted* into the subclavian groove on the under surface of the middle third of the clavicle. It is enveloped by the two layers of the costo-coracoid membrane.

Blood Supply.—From the clavicular branch of the acromio-thoracic (*thoraco-acromial*) artery.

Nerve Supply.—From a filament from the cord formed by the fifth and sixth cervical nerves, the nerve to the subclavius.

Action.—It depresses the shoulder by pulling the clavicle downward and forward. It also draws the clavicle medialward, holding the sternal end of the bone against the sternum. The shoulder girdle being fixed, it is capable of raising and fixing the first rib in inspiration.

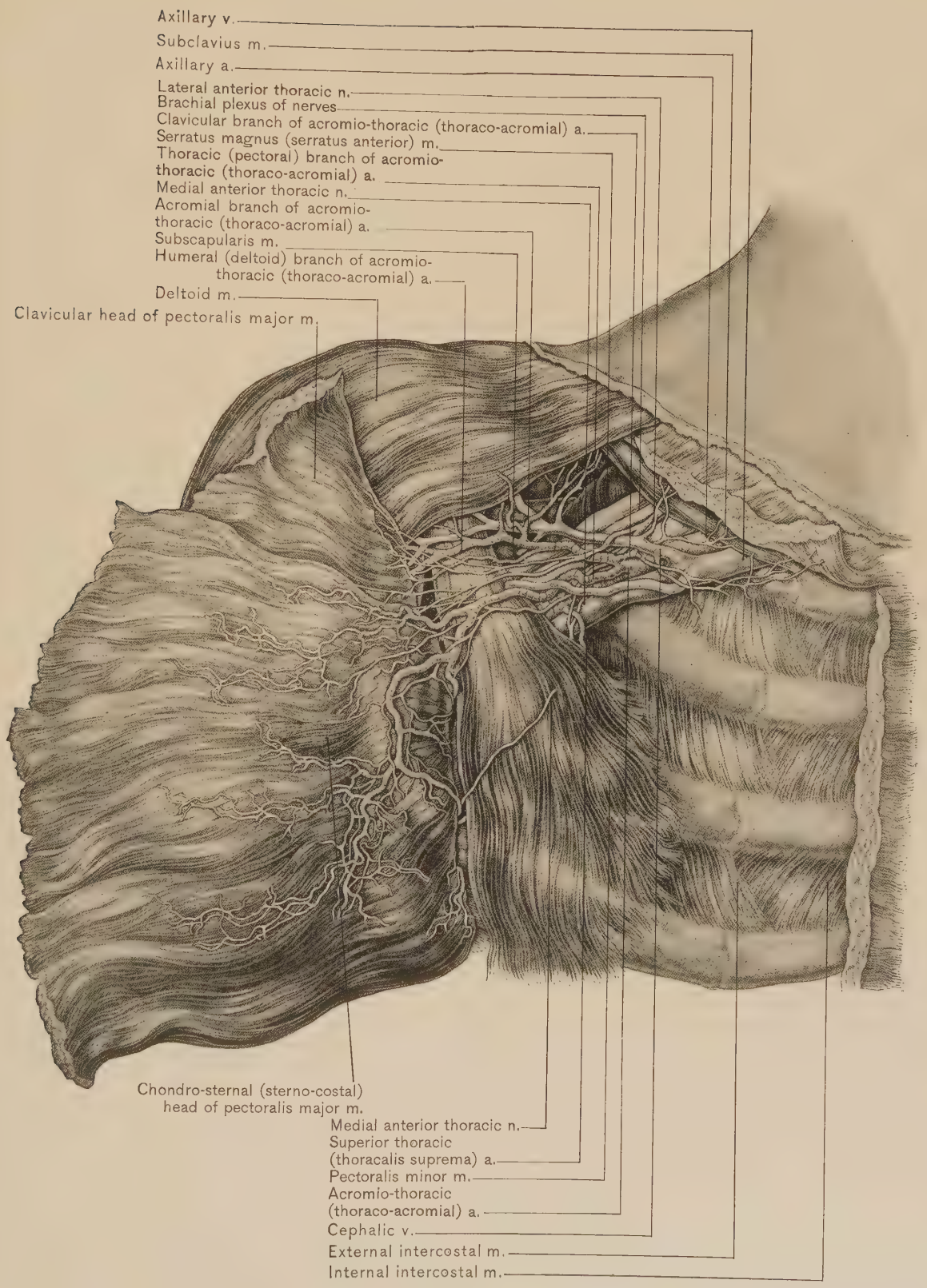
Dissection.—Push the subclavius muscle upward and divide the posterior layer of the costo-coracoid membrane; then divide the costo-coracoid membrane at its attachments to the coracoid process and the upper two intercostal spaces, and dissect it from the structures which pierce it, leaving the latter intact. This will expose the deep infraclavicular triangle.

The **deep infraclavicular triangle** (Plate CXLI).—The base of the deep infraclavicular triangle, directed medialward, is formed by the line of junction of the upper two ribs with their costal cartilages; the apex, directed lateralward toward the coracoid process, is bounded above by the sternal half of the clavicle, and below by the upper border of the pectoralis minor. Its roof is formed by the costo-coracoid membrane and its floor by the upper two ribs and intercostal muscles, the serratus magnus (*serratus anterior*) and the subscapularis muscles. The contents of this triangle are: the *third portion of the axillary vein*, the *first portion of the axillary artery*, the *superior thoracic* (*thoracalis suprema*) *and acromio-thoracic* (*thoraco-acromial*) *arteries and veins*, the *terminal portion of the cephalic vein*, the *lateral and medial anterior thoracic nerves*, *the cords of the brachial*, *plexus*, and the *posterior*, *or long*, *thoracic nerve*. These structures will be described under the dissection of the axilla, where they can be studied to better advantage.

Dissection.—The remaining, or chondro-sternal, portion of the pectoralis major should now be severed in the middle and reflected. This will expose the pectoralis minor enveloped by the deep layer of the pectoral fascia. The *medial anterior thoracic nerve* should be observed as it passes from the pectoralis minor to the pectoralis major. The fascia may then be removed from the pectoralis minor.

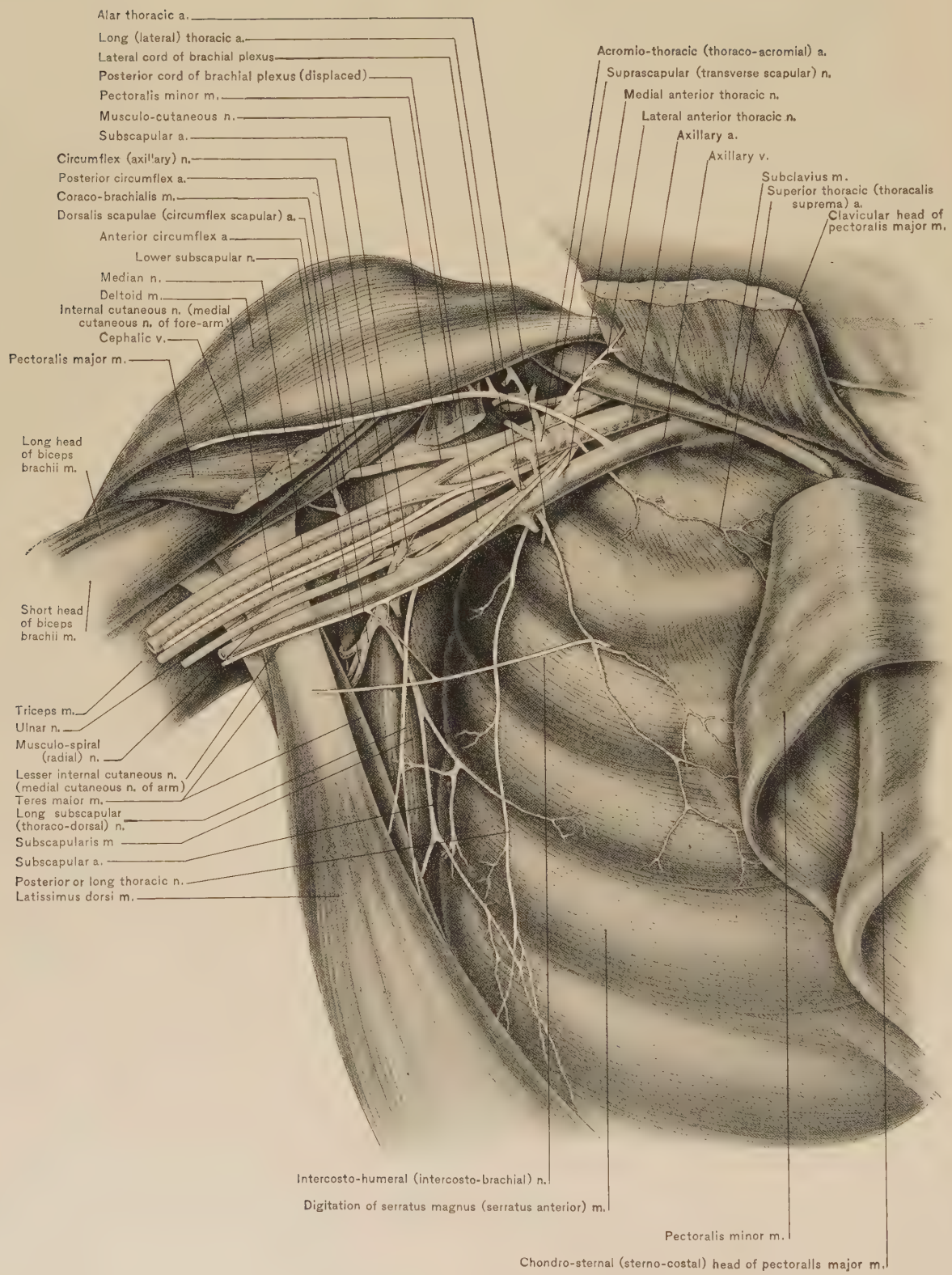
The **pectoralis minor** is an elongated, narrow, triangular muscle *arising*, at its base, from the anterior extremities of the third, fourth, and fifth ribs, and the intervening intercostal fascia. There are often accessory slips of origin either above or below these. Its fibers pass obliquely upward and lateralward, to be *inserted* by a short, flat tendon into the anterior half of the medial surface of the coracoid process and the upper part of the tendon of the coraco-brachialis and biceps brachii muscles. It lies behind, and in contact with the pectoralis major, between the two lamellæ of the deep layer of the pectoral fascia, and immediately in front of the axillary contents. Its upper and lower margins divide

PLATE CXLI.


Axillary v.
Subclavius m.
Axillary a.
Lateral anterior thoracic n.
Brachial plexus of nerves
Clavicular branch of acromio-thoracic (thoraco-acromial) a.
Serratus magnus (serratus anterior) m.
Thoracic (pectoral) branch of acromio-thoracic (thoraco-acromial) a.
Medial anterior thoracic n.
Acromial branch of acromio-thoracic (thoraco-acromial) a.
Subscapularis m.
Humeral (deltoid) branch of acromio-thoracic (thoraco-acromial) a.
Deltoid m.
Clavicular head of pectoralis major m.
Chondro-sternal (sterno-costal) head of pectoralis major m.
Medial anterior thoracic n.
Superior thoracic (thoracalis suprema) a.
Pectoralis minor m.
Acromio-thoracic (thoraco-acromial) a.
Cephalic v.
External intercostal m.
Internal intercostal m.

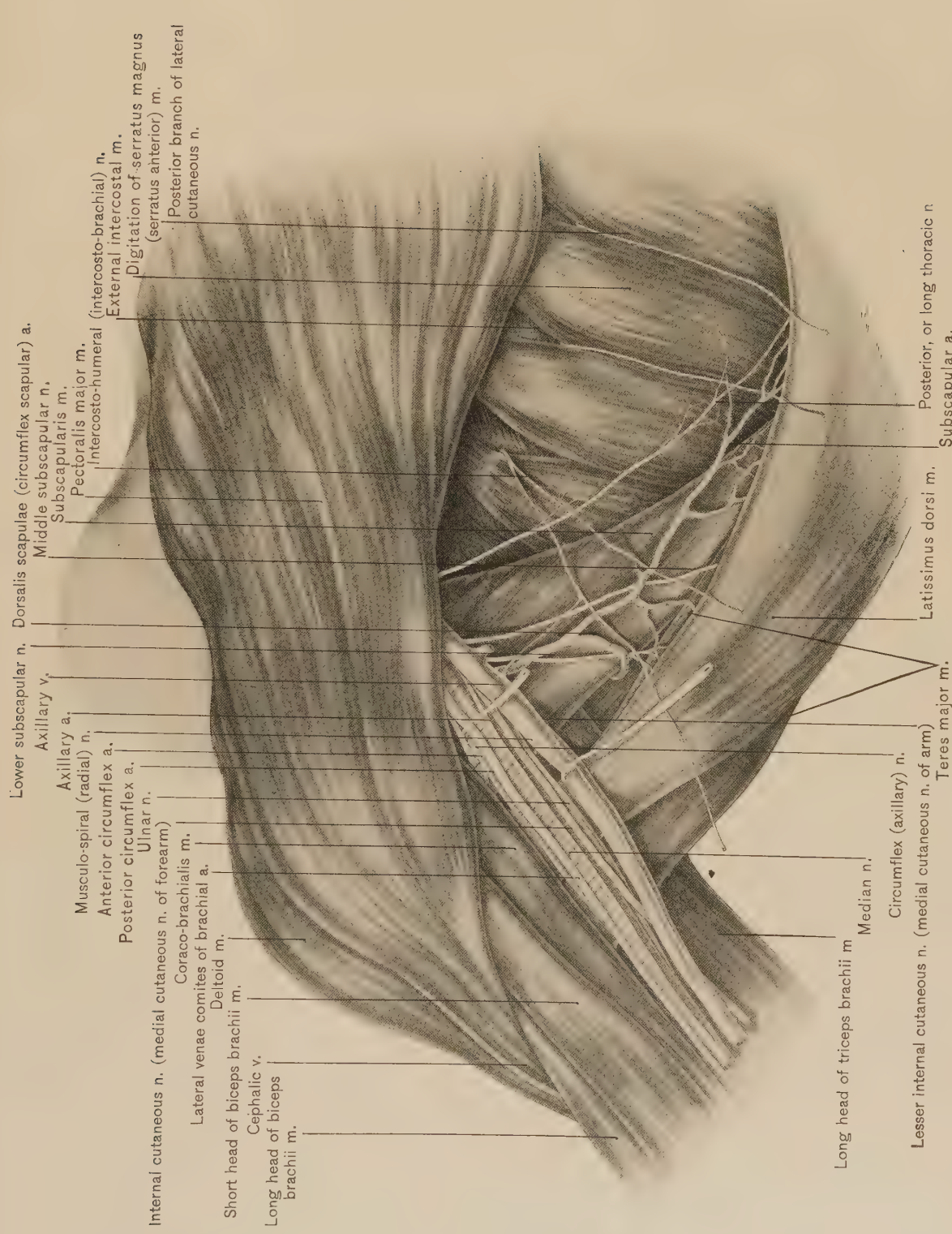
DEEP INFRACLAVICULAR TRIANGLE.

PLATE CXLII.



CONTENTS OF AXILLA SHOWN BY DISSECTION MADE ANTEROPOSTERIORLY.

PLATE CXLIII.



CONTENTS OF AXILLA SHOWN BY DISSECTION MADE FROM INFEROSUPERIORLY.

the axillary artery, over which it passes, into three parts, the first portion being above, the second behind, and the third below the muscle.

Blood Supply.—From the superior (*thoracalis suprema*) and the long (*lateral*) thoracic arteries, which pass along its upper and lower borders, respectively.

Nerve Supply.—From both anterior thoracic nerves, which pierce it to enter the under surface of the pectoralis major.

Action.—It draws the shoulder downward and forward, but not medialward, as is so often stated.

Dissection.—This muscle should now be severed through its middle and reflected as far as its attachments, thus exposing the entire axilla. Upon the opposite side of the body the axillary contents should be dissected from below upward, without disturbing the pectoral muscles, access to the axilla being gained through its base, which is the axillary fascia. The latter is the route by which the surgeon enters in nearly all axillary operations. The study of the axillary contents from these two different directions forms the most practical method of familiarizing the student with their intricate relations (Plates CXLII and CXLIII).

The **axillary fascia.**—(Plates CXXXVII; CXXXVIII.) The layer of fascia inclosing the pectoralis minor joins the layer covering the pectoralis major along the lower, or axillary, border of the latter muscle; this union forms the *axillary fascia.* It is a dense membrane which extends from the lower border of the pectoralis major lateralward to become continuous with the deep fascia of the arm; medialward, to blend with the deep fascia of the chest, and backward to the latissimus dorsi muscle, forming the floor of the axilla. At its junction with the latissimus dorsi (posterior border of the axilla), it divides into two layers, which ensheath that muscle and become continuous with the deep fascia of the back.

The **axilla,** or **arm-pit,** is a pyramidal space or recess, situated between the upper part of the side of the chest and the proximal part of the arm. Its base, directed downward between the inferior borders of the pectoralis major muscle in front and the teres major and latissimus dorsi behind, is formed by the axillary fascia. These borders are known as the anterior and the posterior folds of the axilla. The apex, or narrowest part of the space, to the medial side of the coracoid process and directed upward to the root of the neck, is bounded by the clavicle, the first rib, and the superior margin of the scapula. Through the apex, which is the point of communication between the neck and the axilla, pass the axillary vessels, the brachial plexus of nerves, and the posterior, or long, thoracic nerve, the external respiratory nerve of Bell. The anterior wall of the axilla is formed by the pectoral and subclavius muscles, and the deep pectoral fascia, and the posterior wall by the subscapular, the teres major, and the latissi-

mus dorsi muscles. Laterally these two walls converge. The medial wall is formed by the upper four or five ribs, the intervening intercostal muscles, and the corresponding digitations of the serratus magnus (*serratus anterior*) muscle. The lateral wall is formed by the humerus, the short head of the biceps, and the coracobrachialis muscle; the axillary vessels and nerves being in intimate relation with this lateral wall, make it the most important part of the axilla.

The axilla varies in depth according to the relation of the arm to the side of the chest. It is deepest when the arm is raised at an incline of about forty-five degrees, and shallowest when the arm is strongly abducted. In the latter position its contents are brought nearer to the surface, and therefore it is the position preferred when operating upon the axilla. When palpating the axilla to determine the position of the head of the humerus, the presence or absence of enlarged glands, etc., the arm should be brought near the side, thus facilitating the examination by relaxing the axillary fascia and allowing it to be carried in advance of the finger.

The dense axillary fascia resists the spontaneous rupture of an axillary abscess. The abscess tends to spread upward beneath the pectoral muscles to the root of the neck by way of the apex of the axilla. (For the course taken by purulent collections beneath the pectoral muscles and not within the axilla proper, see description of the arrangement of the layers of the deep pectoral, fascia, p. 51.) When opening the axilla from below for the purpose of evacuating a purulent or other collection, the incision should be made midway between its anterior and posterior folds, and from without medialward and behind and parallel to the long (*lateral*) thoracic artery and long thoracic nerve which run under the pectoralis major, and away from the large blood-vessels and nerves which lie along the lateral axillary wall. By confining the incision to the center of the axilla, the long (*lateral*) thoracic artery (deep external mammary) on the anterior wall, and the subscapular vessels and the long subscapular (*thoracodorsal*) nerve on the posterior wall of the axilla will be avoided. The incision may divide the superficial external mammary artery which, when present, runs through the superficial fascia overlying the axillary fascia.

The *contents* of the axilla are: the axillary artery and vein and their branches; the brachial plexus of nerves, and most of its branches; the lateral cutaneous branches of the intercostal nerves, that of the second being known as the intercosto-humeral (*intercosto-brachial*); the posterior, or long, thoracic nerve; three chains of axillary lymph glands and their vessels, and a large quantity of areolar tissue and fat. Except at the apex, they lie close to the lateral wall and follow it in all its movements.

Dissection.—Upon the side of the body on which the anterior axillary wall has been reflected the areolar tissue and fat should be removed from the other structures in the axilla, in the order enumerated above, while upon the opposite side the space should be dissected from below upward.

The axillary vessels are inclosed in a *sheath* derived from the prevertebral layer of the deep cervical fascia, the anterior wall of which is reinforced by the costo-coracoid membrane. This sheath should be removed in order that the vessels may be more clearly exposed.

The **axillary vein** lies to the medial, or thoracic, side of the axillary artery. It begins at the lower border of the teres major muscle from the union of the two humeral veins and the basilic vein, of which latter it is a continuation, and passes upward along the lateral wall of the axilla as far as the lower border of the first rib, where it becomes the subclavian vein. The axillary vein receives the cephalic vein, the venæ comites of the brachial artery, and branches corresponding to those of the axillary artery, with the exception of branches of the circumflex arteries, which may enter either the subscapular vein or one of the venæ comites of the brachial artery or the cephalic vein. In the upper part of the axilla the relation between the axillary vein and the axillary artery is more intimate than in the lower part. (Relations of the Axillary Artery, p. 65.) The axillary vein, as well as the artery, may be said to consist of three portions, the first and third portions corresponding to the third and first portions of the artery, respectively.

The axillary vein being nearer the surface is more liable to injury than the axillary artery. On account of its size and its close proximity to the heart, a wound of the axillary vein presents the danger of air entering the circulation. On the other hand, the adherence of the costo-coracoid membrane to the sheath of the vessel, and of the sheath, in turn, to the wall of the vein, prevents collapse of the vessel.

Pressure upon the axillary vein, as in forward dislocation of the humerus, or pressure from axillary tumors, a crutch, an axillary pad, or enlargement of the lymph glands, may cause edema of the arm and the forearm. Edema of the arm associated with carcinoma of the breast is a grave symptom, because it indicates involvement of the deep lymphatics, which are in relation with the axillary vessels. Edema appearing shortly after removing the fat and lymphatics of the axilla in an excision of the breast is due to a phlebitis, or to a loss of support previously given the vein by the fat, the lymphatics, and the pectoral muscles.

When opening the axilla for the purpose of excising a growth or removing enlarged glands, the incision should be made along the center of the axilla, extending far enough into the arm to expose the first portion of the axillary vein. The dissection should then be made away from the axillary vein. By this method

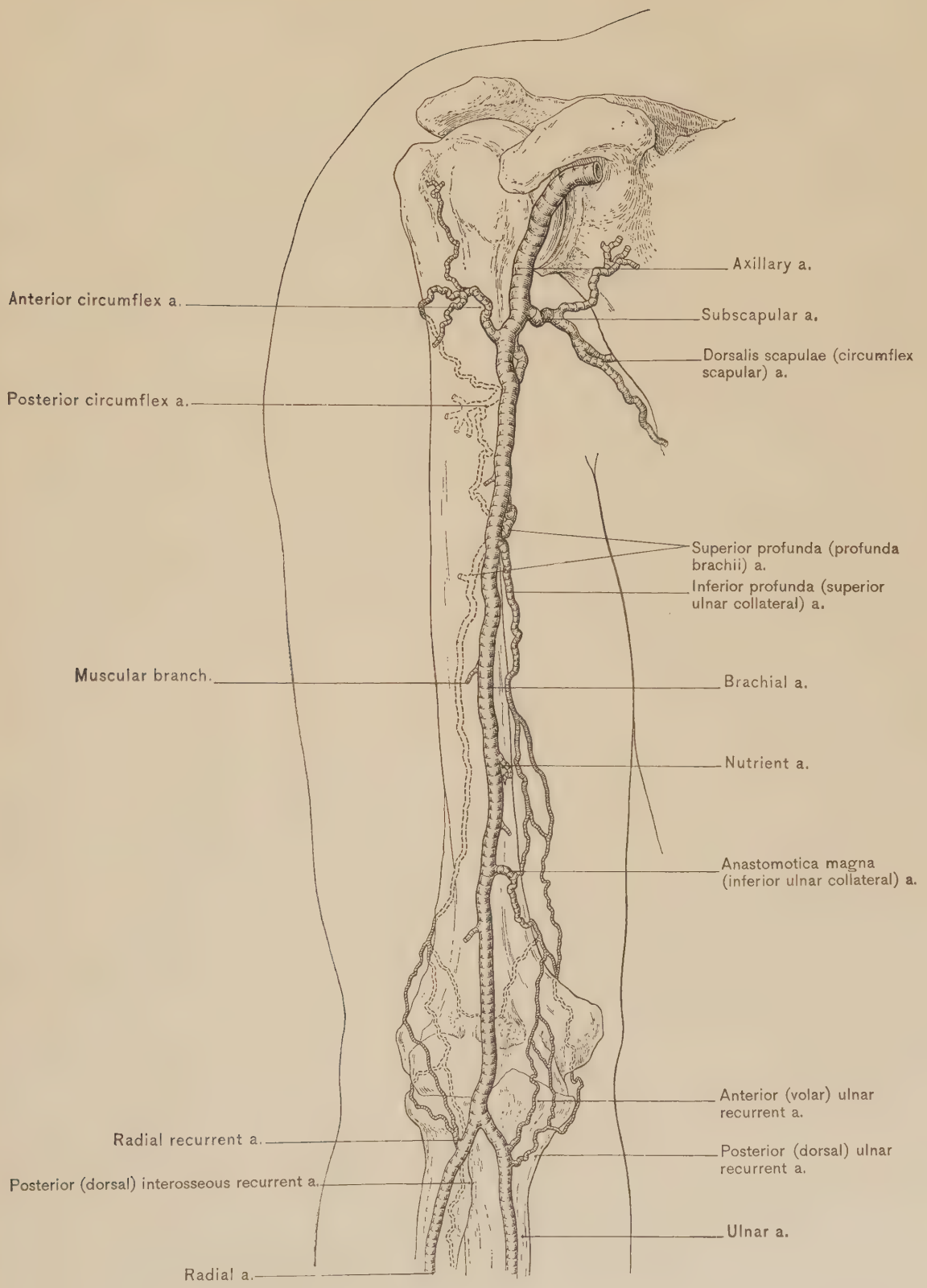
there is less risk of wounding the vein than when working from within outward or from below upward. The practice of removing enlarged glands with the finger through a comparatively small opening in the base of the axilla is dangerous and should be avoided.

The **axillary artery** (Plate CXLIV), the continuation of the subclavian, commences at the lower border of the first rib, passes downward and lateralward through the apex, beneath the pectoral muscles, being at first on the medial wall of the axilla, then crossing the interval between the medial and posterior walls, and then running along the lateral wall and along the medial border of the coracobrachialis muscle to the lower border of the tendon of the teres major, where it becomes the brachial artery. It is accompanied by the axillary vein and the nerves of the brachial plexus. The course of the vessel through the axilla varies with the relation of the arm to the body. With the arm abducted at a right angle with the body, the artery takes an almost straight course, indicated by a line drawn from a point a little to the medial side of the center of the clavicle to the medial side of the tendon of the biceps at the middle of the bend of the elbow. It passes downward along the medial side of the coracoid process and the coracobrachialis muscle at about the junction of the anterior and middle thirds of the axilla. With the arm carried well upward, the artery describes a curve with its concavity directed toward the shoulder; while with the arm at the side, the artery describes a curve with its convexity directed toward the shoulder.

Pressure upon the axillary artery, as in forward dislocation of the humerus or cervical rib, may cause absence of the radial pulse.

In passing through the axilla the relations of the artery vary so that for convenience of description it is divided into three portions. The *first portion* extends from the lower border of the first rib to the upper border of the pectoralis minor; the *second portion*, the shortest, lies behind that muscle; the *third portion*, the longest, extends from the lower border of the pectoralis minor to the lower border of the tendon of the teres major. This last portion is the most accessible, and is the point of election for ligation. A ligature applied to this part of the vessel can be made to encircle it further away from the branches than if applied to either the first or the second portions, and therefore will interfere less with the establishment of collateral circulation. This portion of the vessel also offers a favorable point for digital compression against the upper end of the humerus or, with the finger in the axilla, against the axillary or lateral margin of the scapula. Passing from the latissimus dorsi to join either the pectoralis major or the coraco-brachialis or the biceps brachii muscle, and crossing the third portion of the axillary artery, there is sometimes a muscular slip which may be mistaken for the coraco-brachialis.

PLATE CXLIV.



AXILLARY AND BRACHIAL ARTERIES AND THEIR BRANCHES.

THE FIRST PORTION.—In front of this portion are: the lateral anterior thoracic nerve, the costo-coracoid membrane, the cephalic vein, the acromio-thoracic vessels, the axillary lymph trunk, and the clavicular head of the pectoralis major; to the medial side and overlapping it when the arm is at the side of the body is the axillary vein; with the arm abducted at a right angle with the body, the vein lies entirely to the medial side of the artery; laterally is the brachial plexus; posteriorly is the first intercostal muscle, the first digitation of the serratus magnus (*serratus anterior*), and the posterior (*long*) thoracic nerve. It is approximately two and a half centimeters (one inch) in length. These relations between the vein and artery are important to remember when ligating the first portion of the latter. Young has shown that when the arm is abducted the upper border of the pectoralis minor is on a level with the lower border of the first rib, but as the muscle leaves the side of the thorax to go to the coracoid process it leaves an interspace more than two and a half centimeters (one inch) long in which the artery can be ligated. This part of the artery lies too deep to be compressed. It is better to compress the subclavian above the clavicle. In addition to the difficulty of ligating the artery due to its depth and its varying relations to its companion vein, there are other difficulties due to the occasional entrance of the cephalic into the subclavian vein, by which it crosses the artery at a higher point; or the presence of the enveloping plexus, formed by the lateral and medial anterior thoracic nerves; or the artery may be crossed by one of the roots of the median nerve or by the suprascapular (*transverse scapular*) vein which joins the axillary instead of the external jugular. The *branches* of this portion of the axillary artery are the superior thoracic (*thoracalis suprema*) and the acromio-thoracic (*thoraco-acromial*) arteries.

The **superior thoracic** (**thoracalis suprema**), the first branch of the axillary artery, arises so close to the lower margin of the first rib that it may well be considered the last branch of the subclavian; sometimes it is derived from the acromio-thoracic (*thoraco-acromial*). It winds around the axillary vein and runs along the upper border of the pectoralis minor to supply both pectoral muscles, the serratus magnus (*serratus anterior*), and the contents of the adjacent intercostal spaces; it anastomoses with the intercostal arteries.

The **acromio-thoracic** (**thoraco-acromial**) **artery** is a short trunk, or axis, arising from the axillary artery just above the upper margin of the pectoralis minor and piercing the costo-coracoid membrane. It gives off four divergent branches: the clavicular, the pectoral, the acromial, and the descending, or deltoid. The *pectoral branches* (two or three) go to the pectoral and the serratus magnus (*serratus anterior*) muscles, and anastomose with the intercostal arteries, the intercostal branches of the internal mammary, and the long (*lateral*) thoracic

arteries. They also give branches to the mammary gland. The *acromial branches* pass laterally over the coracoid process and under the deltoid to the top of the acromion, supplying the tissues of this region. They anastomose with the suprascapular (*transverse scapular*), the anterior and posterior circumflex arteries in the deltoid muscle, and form the acromial rete. The *descending*, or *deltoid, branch* passes down the delto-pectoral triangle in relation with the cephalic vein to supply the deltoid and pectoralis major muscles. It anastomoses with the anterior and posterior circumflex arteries and the acromial branch. The *clavicular branch* runs upward and medially supplying the subclavius muscle and the sterno-clavicular articulations. It anastomoses with the superior thoracic (*thoracalis suprema*), the suprascapular (*transverse scapular*) and the first perforating branch of the internal mammary. The *venæ comites of these branches* usually empty into the cephalic, but sometimes into the axillary vein.

The Second Portion.—Anterior to this portion are the pectoralis major and minor muscles; medially are the medial cord of the brachial plexus and the axillary vein, the latter lying a little anterior to the artery, but separated from it by the nerve cord; laterally is the lateral cord of the plexus; posteriorly are the posterior cord of the plexus and the subscapularis muscle, from which both the artery and the nerve cord are separated by a quantity of areolar and fatty tissue. It is three centimeters (one and a quarter inches) long. While it is never ligated at this point, it is frequently exposed while cleaning out the axilla during radical operations on the breast. Its *branches* are the alar thoracic and the long (*lateral*) thoracic.

The *alar thoracic artery* is a small branch distributed to the glands and the areolar tissue of the axilla. Very often it is absent as a separate branch, its place being taken by branches of one of the other thoracic arteries.

The *long* (*lateral*) *thoracic* (deep external mammary) *artery* runs downward and medially along the lower border of the pectoralis minor to the side of the chest. It supplies the pectoral and serratus magnus (*serratus anterior*) muscles and the mammary glands, and anastomoses with the superior thoracic (*thoracalis suprema*), the intercostal, the internal mammary, the subscapular and the acromio-thoracic (*thoraco-acromial*) arteries.

The Third Portion.—Anterior to the upper part of this portion are the superficial and deep fascia and the pectoralis major, while the lower part is covered only by skin and superficial and deep fascia. In front of this part of the artery are the medial head of the median nerve and the internal cutaneous nerve (*medial cutaneous nerve of forearm*); to the medial side are the ulnar nerve, the axillary vein, and the lesser internal cutaneous nerve (*medial cutaneous nerve of arm*), the latter being separated from the artery by the vein; laterally are the

median and musculo-cutaneous nerves and the coraco-brachialis muscle; while posteriorly are the musculo-spiral (*radial*) and the circumflex nerves, the subscapularis muscle, and the tendons of the latissimus dorsi and of the teres major. This part is about seven and one-half centimeters (three inches) long. Its *branches* are the subscapular, the anterior circumflex, and the posterior circumflex.

The *subscapular artery*, the largest branch of the axillary, arises opposite the lateral, or axillary, border of the subscapular muscle. It runs medialward and downward along this border to the inferior angle of the scapula, where it anastomoses with the posterior scapular (*descending branch of transverse cervical*), the larger of the two terminal branches of the transverse cervical, and also with the long (*lateral*) thoracic and the intercostal arteries. In the lower portion of its course it is accompanied by the long subscapular (*thoraco-dorsal*) nerve. It gives branches to the subscapularis, serratus magnus (*serratus anterior*), latissimus dorsi, and teres major muscles and to the glands and the areolar tissue of the axilla. Four centimeters (one and one-half inches) from its origin it gives off a large branch, the *dorsalis scapulæ* (*circumflex scapular*), which winds around the axillary border of the scapula between the subscapularis and teres minor, passing through the triangular subdivision of that general triangular space, situated at the axillary border of the scapula, to the dorsum of this bone, where it anastomoses with the suprascapular (*transverse scapular*) and posterior scapular (*descending branch of transverse cervical*) arteries. The space through which it passes is bounded by the subscapularis, the teres minor, the teres major, and the long head of the triceps. A small branch is given off from the dorsalis scapulæ (*circumflex scapular*) which enters the subscapular fossa beneath the subscapular muscle. A line drawn along the axillary border of the scapula to its inferior angle indicates the course of the subscapular artery.

The **subscapular triangle** is bounded above by the subscapular and the teres minor muscles, below by the teres major, and on its lateral side by the surgical neck of the humerus. It is subdivided by the long head of the triceps into the triangular space proper, through which pass the dorsalis scapulæ (*circumflex scapular*) vessels, and the quadrilateral space, through which pass the posterior circumflex vessels and the circumflex (*axillary*) nerve.

The *posterior circumflex*, the larger of the two circumflex arteries, arises from the posterior aspect of the axillary artery, below the lower border of the subscapular muscle. Accompanied by its veins and the circumflex (*axillary*) nerve, it passes backward through the quadrilateral subdivision of the subscapular triangle, winding around the surgical neck of the humerus to reach the under surface of the deltoid muscle, and to supply this muscle and also the shoulder-joint and the integument. It is to avoid dividing the artery and the nerve that

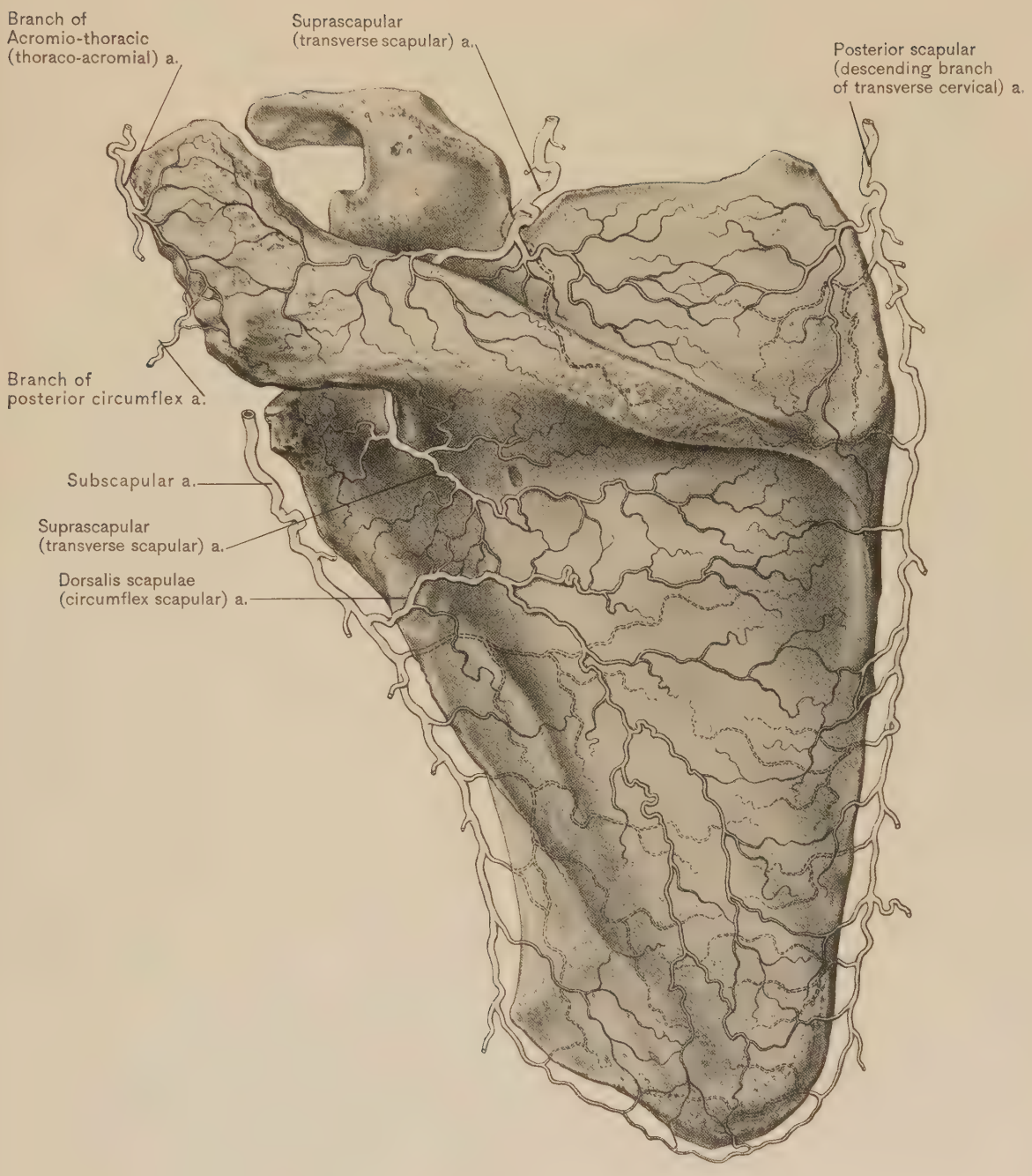
the operation of resection of the head of the humerus is done anteriorly instead of posteriorly. The posterior circumflex anastomoses with the following arteries: the acromio-thoracic (*thoraco-acromial*), the suprascapular (*transverse scapular*), the subscapular, the anterior circumflex and the ascending branch of the superior profunda (*profunda brachii*). The posterior circumflex, when not a branch of the axillary artery, may spring from the brachial or the superior profunda (*profunda brachii*) or it may arise from the axillary as a common trunk with the subscapular. (Plate CXLV.)

The *anterior circumflex artery* arises from the lateral aspect of the axillary, runs lateralward over the tendon of the latissimus dorsi and beneath the coracobrachialis and the two heads of the biceps, and over the surgical neck of the humerus to the under surface of the deltoid, which it supplies. In excision of the shoulder-joint this artery is often difficult to ligate, as it lies close to the bone. A small branch, the *bicipital*, given off where it crosses the bicipital groove (*intertubercular sulcus*), passes up the groove with the long tendon of the biceps and supplies the shoulder-joint and the head of the humerus. The anterior circumflex anastomoses with the posterior circumflex and the acromio-thoracic (*thoraco-acromial*) arteries. Above these circumflex arteries, or rather below the inferior scapular, is a convenient point for ligating the axillary artery in the axilla.

The **brachial, or axillary, plexus of nerves** is formed by the anterior divisions of the fifth, sixth, seventh, and eighth cervical nerves and first dorsal (*thoracic*) nerve (Plate CXLVI). Above, the plexus is reinforced by a small twig of communication which passes from the fourth to the fifth cervical nerve, while below, a similar connecting twig often passes upward from the second to the first dorsal (*thoracic*) nerve. In the neck it consists of three trunks, an upper, a middle and a lower, and in the axilla, of three cords, a lateral, a medial and a posterior. The three trunks, seen in the deep dissection of the side of the neck, are as follows: The upper trunk is formed by the anterior primary divisions of the fifth and sixth cervical nerves, the middle trunk by the anterior primary division of the seventh cervical, and the lower trunk by the anterior primary divisions of the eighth cervical and first dorsal (*thoracic*) nerves. These trunks lie in relation with the second and third portions of the subclavian artery, the upper and middle trunks lying above the artery, and the lower one partly behind it.

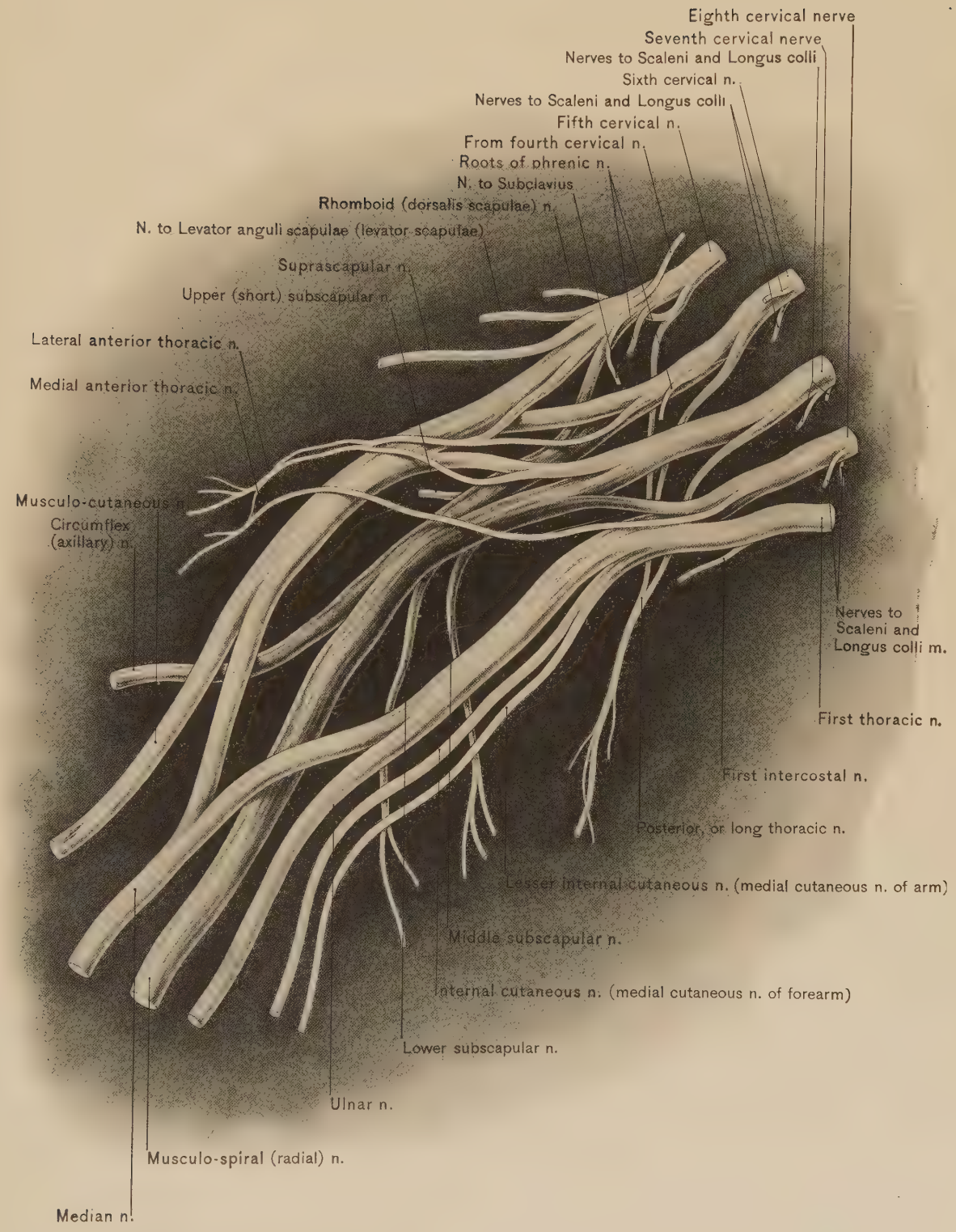
These three trunks, each of which divides into an anterior and a posterior branch, enter the axilla by way of its apex, lying above and to the lateral (acromial) side of the first portion of the axillary artery. The anterior branches of the upper and middle trunks unite to form the lateral cord of the plexus, which lies on the lateral side of the second portion of the axillary artery, and the anterior

PLATE CXLV.



ANASTOMOSES OF ARTERIES AROUND THE SCAPULA.

PLATE CXLVI.


Eighth cervical nerve
Seventh cervical nerve
Nerves to Scaleni and Longus colli
Sixth cervical n.
Nerves to Scaleni and Longus colli
Fifth cervical n.
From fourth cervical n.
Roots of phrenic n.
N. to Subclavius
Rhomboid (dorsalis scapulae) n.
N. to Levator anguli scapulae (levator scapulae)
Suprascapular n.
Upper (short) subscapular n.
Lateral anterior thoracic n.
Medial anterior thoracic n.
Musculo-cutaneous n.
Circumflex (axillary) n.
Nerves to Scaleni and Longus colli m.
First thoracic n.
First intercostal n.
Posterior, or long thoracic n.
Lesser internal cutaneous n. (medial cutaneous n. of arm)
Middle subscapular n.
Internal cutaneous n. (medial cutaneous n. of forearm)
Lower subscapular n.
Ulnar n.
Musculo-spiral (radial) n.
Median n.

BRACHIAL, OR AXILLARY, PLEXUS OF NERVES.

branch of the lower trunk constitutes the medial cord of the plexus, which lies on the medial side of the artery. The posterior branches of all three trunks unite to form the posterior cord of the plexus, which lies posterior to the second portion of the axillary artery. Sometimes the posterior cord is formed simply by the union of the posterior branches of the upper and middle trunks, while the posterior branch of the lower trunk, small in comparison with the others, unites with the musculo-spiral (*radial*) branch of the posterior cord. The first two stages in the formation of the plexus take place in the neck, the third, posterior to the clavicle and the last, in the axilla.

Pressure upon the brachial plexus may be produced by an axillary tumor, a cervical rib, an axillary aneurysm, anterior luxation of the humerus, fracture of the clavicle, or by mechanical pressure of a crutch, or an axillary pad used in the treatment of fracture of the humerus.

The *branches* given off from the brachial plexus below the clavicle are: the lateral and medial anterior thoracic, the three subscapular, the circumflex (*axillary*), the musculo-cutaneous, the median, the ulnar, the internal cutaneous (*medial cutaneous of forearm*), the lesser internal cutaneous (*medial cutaneous of arm*), and the musculo-spiral (*radial*). Of these branches the lateral anterior thoracic, the lateral head of the median, and the musculo-cutaneous arise from the lateral cord; the three subscapular, the circumflex (*axillary*) and the musculo-spiral (*radial*), from the posterior cord, and the medial head of the median, the ulnar, the internal cutaneous (*medial cutaneous of forearm*), the lesser internal cutaneous (*medial cutaneous of arm*), and the medial anterior thoracic, from the medial cord.

The **lateral, or superficial, anterior thoracic nerve** is derived from the beginning of the lateral cord, just below the clavicle, passes medialward across the axillary vessels, and pierces the costo-coracoid membrane to enter the under surface of, and to supply the pectoralis major. It communicates with the medial anterior thoracic nerve.

The **medial, or deeper, anterior thoracic nerve,** smaller than the lateral, is derived from the medial cord just below the clavicle, and passes forward between the axillary artery and vein, sometimes piercing the sheath of the latter. It enters the pectoralis minor, to which it gives off branches, and then pierces it to enter the pectoralis major. It also gives off a branch which, with a branch from the lateral anterior thoracic nerve, forms a loop around the medial side of the axillary artery, from which loop other branches pass to enter the pectorales major and minor muscles.

The **three subscapular nerves,** the first, the middle, and the lower, arise from the posterior cord. The *first,* or *short* (*upper*), *subscapular* supplies the

upper and posterior part of the subscapular muscle; the *middle*, or *long*, *subscapular* (*thoraco-dorsal*) accompanies the subscapular artery and supplies the latissimus dorsi muscle; the *second*, or *lower*, *subscapular* supplies the axillary border of the subscapular muscle and the teres major muscle.

The **circumflex** (**axillary**) **nerve** arises from the posterior cord, passes downward and lateralward behind the third portion of the axillary artery, turns around the lower border of the subscapular muscle to the quadrilateral subdivision of the subscapular triangle, where, with the posterior circumflex artery, it leaves the axilla. Between the axillary border of the scapula and the teres minor it gives off an articular branch which pierces the capsular ligament to supply the shoulder-joint, after which it divides into a superior and an inferior branch. The *superior branch* (*lateral cutaneous nerve of the arm*) accompanies the posterior circumflex artery around the back of the surgical neck of the humerus and under the deltoid to its anterior border, supplying this muscle and the skin over its lower part. The *inferior branch* (*muscular branch*) sends several twigs to the back part of the deltoid, and one twig with a gangliform enlargement, due to a thickening of fibrous tissue on its trunk, to the teres minor, after which it passes under the deltoid and around the lower part of its posterior border to supply the skin over the long head of the triceps and the lower two-thirds of the posterior part of the deltoid. A *bicipital branch* arises from the end of the circumflex (*axillary*) nerve and passes up the bicipital groove (*intertubercular sulcus*) to supply the tendon of the long head of the biceps, the proximal end of the humerus, and the shoulder-joint. In luxation of the humerus the circumflex (*axillary*) nerve is sometimes stretched over the head of the humerus, and paralysis of the deltoid may ensue.

The **musculo-cutaneous nerve** arises from the lateral cord, opposite the lower border of the pectoralis minor. At its origin it lies close to the lateral side of the axillary artery. It then passes lateralward and downward to the coraco-brachialis muscle, which it pierces and supplies, undergoing subdivision in its substance. It supplies the coraco-brachialis, the coracoid head of the biceps brachii and the brachialis muscles. Division of the nerve at its origin results in paralysis of the flexor muscles of the elbow. Its terminal branches supply sensation along the lateral side of the forearm.

The **median nerve**, the most superficial of the three chief nerves of the arm, is formed at the lateral side, or in front of the third portion of the axillary artery, generally beneath the pectoralis minor muscle, by the Y-shaped union of its lateral and medial heads. The lateral head arises, with the musculo-cutaneous, from the lateral cord; the medial head arises with the ulnar, from the medial

cord, and crosses in front of the third portion of the axillary artery. This nerve is the one most frequently injured in wounds of the axilla.

The **ulnar nerve** arises from the medial cord in common with the medial head of the median. It lies upon the medial side of the third portion of the axillary artery, between it and the axillary vein, and then passes down the medial side of the arm upon the medial surface of the triceps, piercing the medial intermuscular septum together with the inferior profunda (*superior ulnar collateral*) artery at the distal third of the arm to reach the space between the medial condyle (*epicondyle*) and the olecranon.

The **internal cutaneous nerve** (**medial cutaneous nerve of the forearm**) arises from the medial cord and passes downward on the medial side of the axillary artery, between this vessel and the ulnar nerve.

The **lesser internal cutaneous nerve** (**medial cutaneous nerve of the arm**) (nerve of Wrisberg), the smallest branch of the plexus, arises from the medial cord, passes behind and along the medial side of the axillary vein, where it is joined by the intercosto-humeral (*intercosto-brachial*), which is the lateral cutaneous branch of the second intercostal nerve. The lesser cutaneous nerve (*medial cutaneous nerve of the arm*) is separated from the ulnar nerve and from the third portion of the axillary artery by the axillary vein.

The **musculo-spiral** (**radial**), the largest branch of the plexus, is one of the two terminal branches of the posterior cord, the other being the circumflex (*axillary*) nerve. It lies behind the third portion of the axillary artery and in front of the subscapular, latissimus dorsi, and teres major muscles. This nerve is most important because it supplies all the extensor and all the supinator muscles except the biceps. It is the nerve that is least likely to be injured in wounds of the axilla, but it is frequently injured by contusions, or in fractures of the middle of the shaft of the humerus. It must be carefully avoided in operative procedures in this region.

The **intercosto-humeral** (**intercosto-brachial**) **nerve,** the lateral cutaneous branch of the second intercostal nerve, passes lateralward across the axilla from the medial wall to the medial side of the arm. It joins the lesser internal cutaneous nerve (*medial cutaneous nerve of the arm*), pierces the deep fascia (floor of the base of the axilla), and terminates in filaments which are distributed to the skin of the medial and the dorsal surfaces of the arm. This branch is larger than the other lateral cutaneous branches of the intercostal nerves and differs from them in that it does not divide into anterior and posterior branches. It is not uncommon to meet with two and even three intercosto-humeral (*intercosto-brachial*) nerves, the second being formed by the posterior branch of the lateral cutaneous branch of the third intercostal, and accompanying the first in its distribution,

the third one, when present, coming from the fourth intercostal nerve. All of the lateral cutaneous branches of the intercostal nerves emerge from the intercostal spaces midway between the vertebræ and the sternum, and, with the exception of the second, divide into an anterior and a posterior branch. The first intercostal nerve does not, as a rule, give off a lateral cutaneous branch.

The **posterior, or long, thoracic nerve,** the external respiratory nerve of Bell, a branch of the brachial plexus given off above the clavicle, lies along the medial wall of the axilla. It arises by three roots, the upper two springing from the fifth and sixth cervical nerves, and the lower one from the seventh cervical nerve. The upper two roots pierce the scalenus medius muscle, while the lower root passes in front of it. Usually the two portions of the nerve, formed by the union of the upper two roots and the lower root, pass into the axilla separately behind the brachial plexus and vessels, where they join to form the common trunk which supplies the serratus magnus (*serratus anterior*) muscle, upon whose lateral surface the nerve lies.

The axillary lymph glands, sixteen to thirty-six in number (most of which were removed during the dissection of the areolar and fatty tissue in exposing the axilla), receive the lymph vessels from the upper extremity, from the back, from the anterior portion of the chest, and from the mammary gland. They are united by collecting stems but are arranged in more or less distinct chains as follows: a *brachial chain,* consisting of from four to seven large nodes, lies in relation to the medial side of the first portion of the axillary vein. It receives *afferents* from the superficial and the deep lymphatics of the arm; its *efferents* pass partly to the lymphatics of the intermediate chain and partly to the subclavian lymph trunk. An *anterior pectoral chain* of from four to fourteen small nodes lies over the second and third intercostal spaces along the line of the long (*lateral*) thoracic artery in the angle between the lower border of the pectoralis major and the serratus magnus (*serratus anterior*) muscles. It receives *afferents* from the lower lateral wall of the thorax and subjacent muscles; its *efferents* pass to the intermediate chain. A *subclavicular,* or *infraclavicular, chain* of from six to twelve nodes lies near the apex of the axillary space partly beneath and partly above the upper border of the pectoralis minor muscle. Its *afferents* are derived either directly or indirectly through the central, or intermediate, chain from the efferents of all the other groups of axillary nodes; its *efferents,* with the exception of one or more which pass to one of the lower deep cervical lymph nodes, unite to form the subclavian lymph trunk. A *central,* or *intermediate, chain* consists of from two to six large nodes situated in the central part of the axillary space between the lateral chest wall and the upper part of the long thoracic vein as it turns lateralward to enter the axillary vein. It receives *afferents* from the

anterior, the subscapular and the brachial chains; its *efferents* pass to the infraclavicular glands. A *posterior*, or *subscapular, chain* consists of six or seven nodes along the subscapular artery together with two or three nodes on the dorsal surface of the scapula between the teres major and minor muscles. Its *afferents* are derived from the lower part of the neck, the dorsal portion of the thorax, and from the scapular region; its *efferents* pass mainly to the intermediate group of lymph nodes. The efferent vessels from all the axillary glands resolve themselves into four lymph-trunks, which course along the subclavian vein and terminate upon the right side in the right lymph duct, and on the left side in the thoracic duct. The relation of the central, or intermediate, chain to the axillary vein is important because when these glands are diseased they are apt to be adherent to the vessel and its sheath, and at operation the vein may be wounded and thus necessitate excision of a portion of the vessel. Enlarged axillary glands may press upon the axillary vein and produce edema of the arm. Edema of the arm may also follow removal of the glands and the areolar tissue of the axilla. The very close association of the important structures found in the apex of the axilla demands the closest attention and most careful handling during any operative procedure in this region.

The areolar and adipose tissue which occupies the axilla fills up the intervals between the other and more important structures. It is redder in color and more granular and watery than similar tissue elsewhere in the body. Posteriorly it is continuous with the tissue that separates the subscapular and the serratus magnus (*serratus anterior*); anteriorly it is a continuation of the tissue between the pectoral muscles and the thoracic wall to the sternal margin; superiorly, from the side of the neck, it is continuous with the subclavicular tissue; inferiorly, from the side of the arm along the plexus of vessels and nerves, it is continuous with the cellular tissue of the scapular region and the anterior and posterior brachial spaces. This continuity of the axillary cellular tissue accounts for the possible diffusion of a collection of pus in the axilla to the neck, the back, the anterior thoracic wall, and the arm. It also emphasizes the importance of draining these distant sites, especially in late operations, in order to avoid destruction of the axillary cellular tissue with the possible result of the development of adhesions which would interfere with the free movements of the shoulder.

Dissection.—Upon the opposite side of the body the axilla should be dissected from below upward. Remove the skin and superficial fascia, as described, and expose both the deep, or pectoral, and the axillary fascia.

The axillary fascia may be removed either in one flap or it may be divided longitudinally and reflected laterally, the dissection being carried far enough beyond the lower borders of the folds of the axilla to expose them thoroughly.

In removing the axillary fascia care should be taken to disturb as little as possible the areolar tissue of this space which is closely connected with the upper surface of the fascia. The areolar tissue can now be removed, exposing first the intercosto-humeral (*intercosto-brachial*) nerve. The other structures seen in this dissection are, along the lateral wall: the axillary vein and artery, the central chain of lymph glands, and the brachial plexus of nerves; along the posterior wall, the long subscapular (*thoraco-dorsal*) nerve, accompanying the subscapular artery and vein, the lower and short (*upper*) subscapular nerves, and the posterior chain of lymph glands; along the medial wall, the long thoracic nerve; along the anterior wall, the long thoracic (*lateral thoracic*) artery and vein, and the anterior pectoral chain of lymph glands.

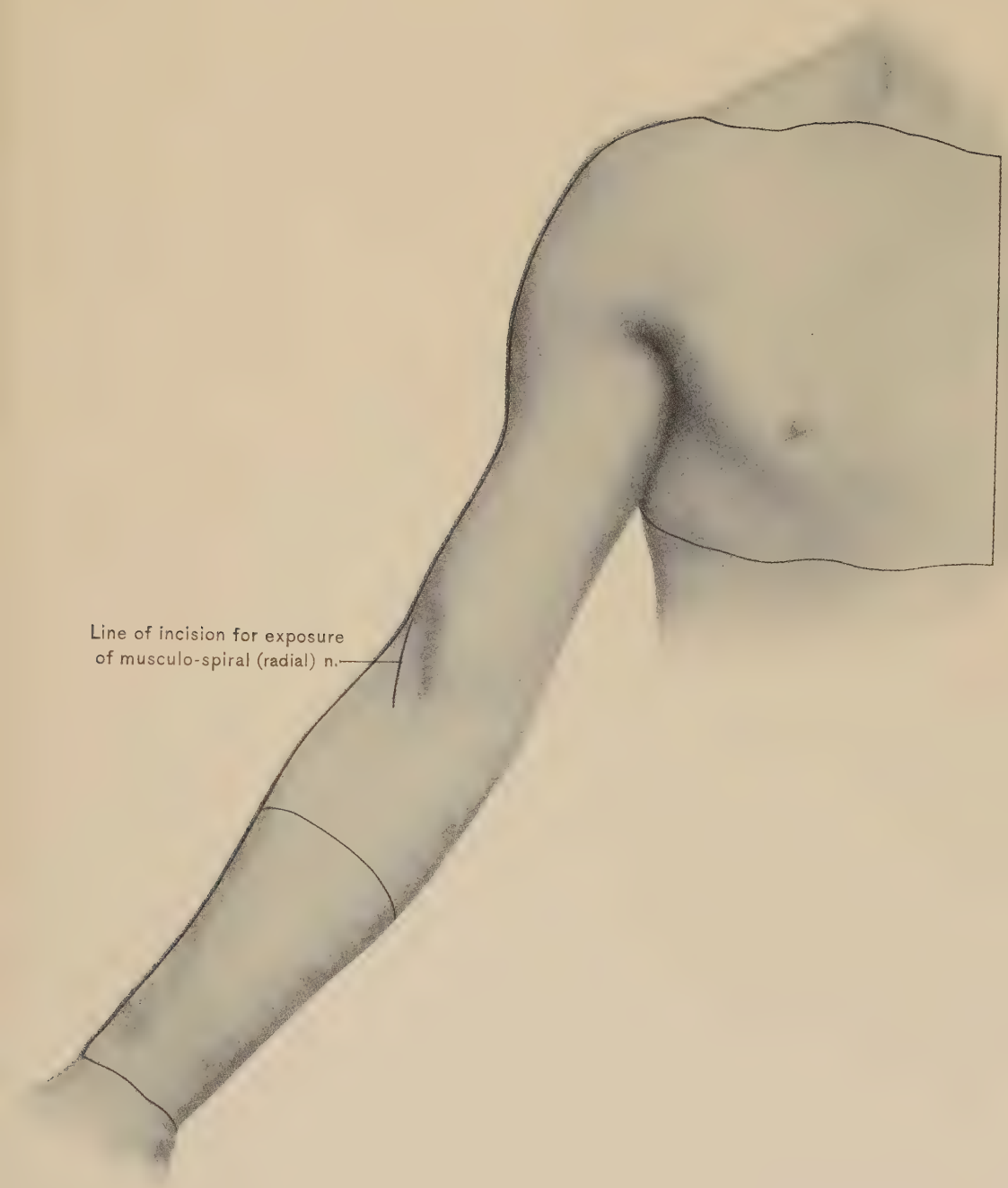
THE FRONT OF THE ARM

Dissection (Plate CXLVII).—Continue the incision already made upon the radial side of the arm to a point on the radial side of the forearm, about seven centimeters (three inches) below the lateral condyle (*epicondlye*). From the distal end of this incision make another transversely across the front of the forearm. Reflect the skin medially as one large flap, and expose the superficial fascia with its ramifying nerves and vessels.

The Superficial Fascia.—This fascia is composed of a superficial layer, consisting mainly of adipose tissue, and a deep layer, fibrous in structure and in direct contact with the deep fascia. Between the two layers are the superficial nerves, vessels, and lymphatics. In the fascia upon the radial side of the arm are found the cutaneous branches of the circumflex (*axillary*) nerve near the deltoid insertion, and below these the lateral cutaneous branches of the musculo-spiral (*radial*) nerve, while immediately above the elbow the musculo-cutaneous nerve becomes subcutaneous on the lateral side of the tendon of the biceps. In addition to these nerves, the cephalic vein is seen on the lateral side of the arm. In the fascia on the medial side of the arm are found the intercosto-humeral (*intercosto-brachial*) nerve, the internal cutaneous branch of the musculo-spiral (*radial*) nerve (*posterior cutaneous nerve of arm*), the internal cutaneous (*medial cutaneous nerve of forearm*) and lesser internal cutaneous (*medial cutaneous nerve of arm*) and the basilic vein. In order to trace these nerves and vessels remove the superficial fascia, being careful not to sever the structures which enter it from beneath. As each nerve or vessel is exposed, trace it through the superficial fascia. (Plate CXLVIII.)

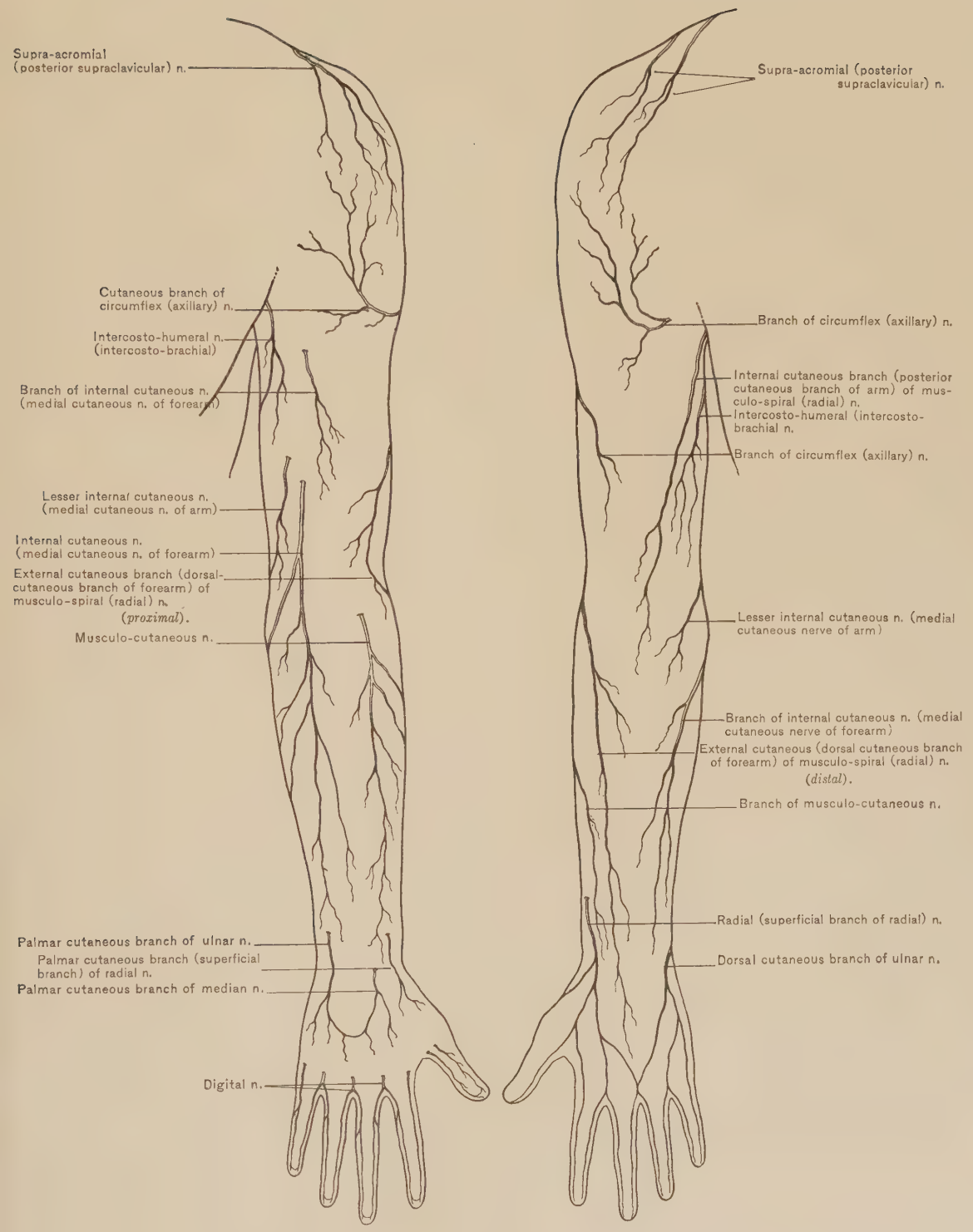
The **cutaneous branches** of the superior division of the **circumflex** (**axillary**) **nerve** pierce the deltoid near its insertion and are distributed to the skin over the lower part of this muscle; the end of the inferior division of the circumflex

PLATE CXLVII.



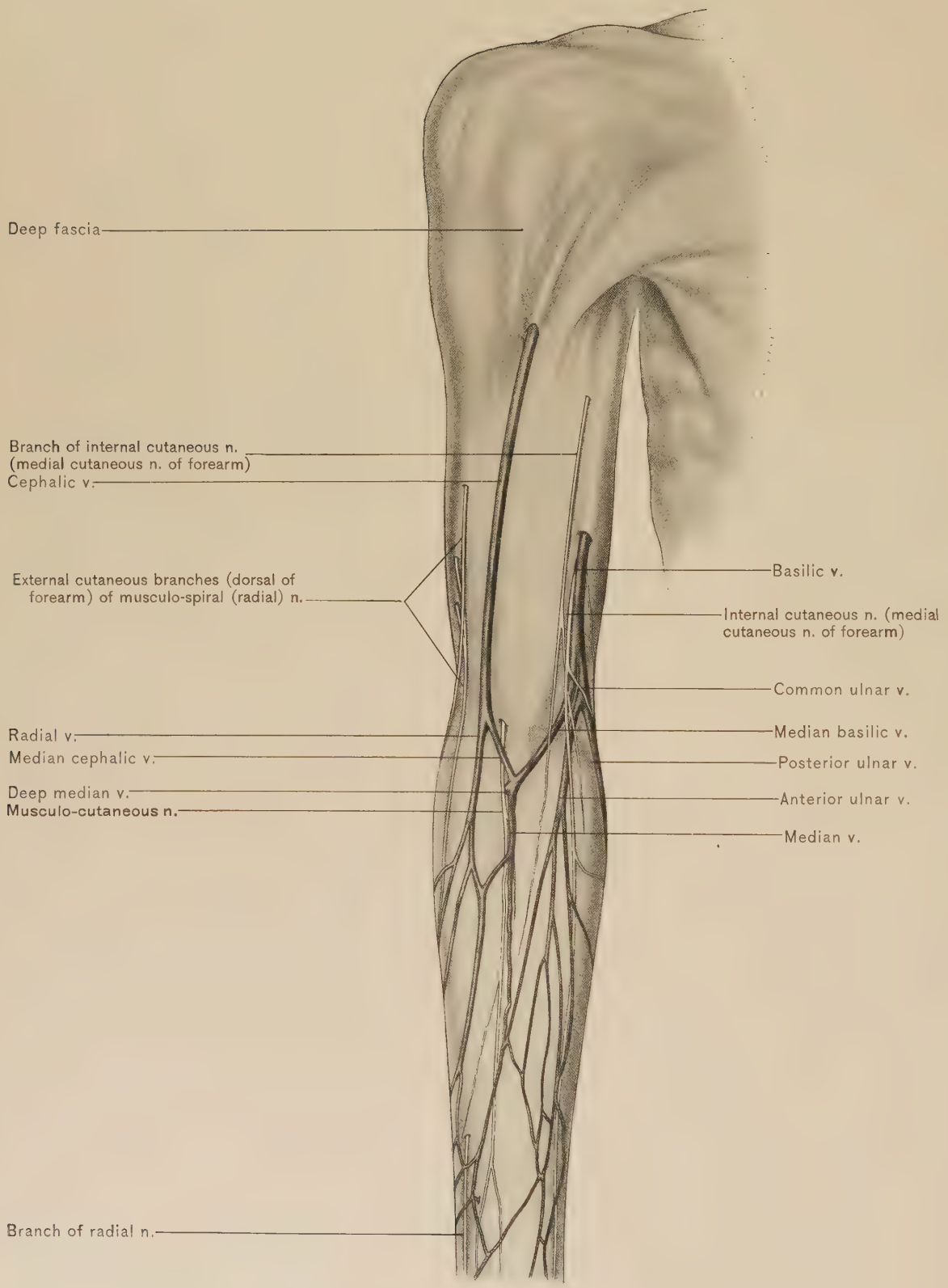
INCISIONS FOR DISSECTIONS.

PLATE CXLVIII.


Supra-acromial (posterior supraclavicular) n.
Cutaneous branch of circumflex (axillary) n.
Intercosto-humeral n. (intercosto-brachial)
Branch of internal cutaneous n. (medial cutaneous n. of forearm)
Lesser internal cutaneous n. (medial cutaneous n. of arm)
Internal cutaneous n. (medial cutaneous n. of forearm)
External cutaneous branch (dorsal-cutaneous branch of forearm) of musculo-spiral (radial) n. (*proximal*).
Musculo-cutaneous n.
Palmar cutaneous branch of ulnar n.
Palmar cutaneous branch (superficial branch) of radial n.
Palmar cutaneous branch of median n.
Digital n.
Supra-acromial (posterior supraclavicular) n.
Branch of circumflex (axillary) n.
Internal cutaneous branch (posterior cutaneous branch of arm) of musculo-spiral (radial) n.
Intercosto-humeral (intercosto-brachial n.
Branch of circumflex (axillary) n.
Lesser internal cutaneous n. (medial cutaneous nerve of arm)
Branch of internal cutaneous n. (medial cutaneous nerve of forearm)
External cutaneous (dorsal cutaneous branch of forearm) of musculo-spiral (radial) n. (*distal*).
Branch of musculo-cutaneous n.
Radial (superficial branch of radial) n.
Dorsal cutaneous branch of ulnar n.

CUTANEOUS NERVES OF ARM AND FOREARM.

PLATE CXLIX.



SUPERFICIAL VEINS OF FRONT OF ARM AND FOREARM.

(*axillary*) nerve emerges from beneath the posterior edge of the deltoid, whence it ascends subcutaneously to supply the skin over the long head of the triceps and the lower two-thirds of the back of the deltoid.

The **superior and inferior external cutaneous branches** (**dorsal cutaneous nerves of forearm**) of the **musculo-spiral** (**radial**) **nerve** emerge through the deep fascia at about the middle of the radial side of the arm. The *superior* branch accompanies the cephalic vein to the front of the elbow and supplies the skin of the distal half of the front of the arm. The *inferior* branch pierces the deep fascia below the deltoid insertion, whence it passes downward to supply the skin on the radial side of the distal half of the arm, the elbow, and the radial side of the forearm, communicating near the wrist with the posterior branch of the external, or musculo-cutaneous, nerve.

The **internal cutaneous nerve** (**medial cutaneous nerve of forearm**) at first lies on the lateral side of the axillary artery with the ulnar and the medial head of the median nerve; in the proximal half of the arm it lies anterior to the brachial artery. In company with the basilic vein, it pierces the deep fascia of the medial side of the arm at the junction of the intermediate and distal thirds, and divides into an anterior (*volar*) and a posterior (*ulnar*) branch. The anterior (*volar*) branch passes downward over the elbow, either in front of or behind the median basilic vein, to supply the skin of the front and the radial side of the forearm. At the wrist it communicates with a cutaneous branch of the ulnar nerve. The posterior (*ulnar*) branch communicates with the lesser internal cutaneous nerve (*medial cutaneous nerve of arm*) above the elbow, and then passes downward behind the medial condyle to supply the skin over the posterior and medial aspect of the forearm, and communicates with the dorsal branch of the ulnar nerve above the wrist-joint. The internal cutaneous nerve also gives off a cutaneous branch which arises high up, pierces the deep fascia at the lower border of the posterior fold of the axilla, and goes to the skin of the ulnar side and the front of the arm.

The **lesser internal cutaneous nerve** (**medial cutaneous nerve of arm**) and the **internal cutaneous branch** (**posterior cutaneous nerve of arm**) of the musculo-spiral (*radial*) nerve are described at p. 75.

Superficial Arteries.—The arteries which ramify in the superficial fascia of the arm, enumerated from above downward, are: the acromio-thoracic (*thoraco-acromial*), the anterior and posterior circumflex, the superior profunda (*profunda brachii*) and inferior profunda (*superior ulnar collateral*), the muscular, and the anastomotica magna (*inferior ulnar collateral*).

Superficial Veins (Plate CXLIX).—The veins in the superficial fascia of the arm are of special interest because of their symmetric arrangement and surgical

importance, especially those in front of the elbow which are the ones selected in venesection, blood-letting, intravenous medication, and in saline infusion or blood transfusion. These superficial veins carry the larger part of the blood from the parts below. Like veins generally, they are subject to frequent variations, but as a rule conform to the following plan:

The **cephalic vein** is formed by the junction of the radial and the median cephalic veins in the groove between the supinator longus (*brachio-radialis*) and the lower, tapering end of the biceps brachii muscle. It passes upward over the lateral edge of the biceps and, after piercing the deep fascia, dips into the delto-pectoral triangle, where it is accompanied by the descending branch of the acromio-thoracic (*thoraco-acromial*) artery. Just below the middle of the clavicle it pierces the costo-coracoid membrane and empties into the third portion of the axillary vein.

The **median cephalic vein** is a short, venous trunk, from four to six centimeters (one and a half to two and a half inches) in length, connecting the distal end of the cephalic vein with the proximal end of the median vein of the forearm, from which it arises in common with the median basilic, about opposite the distal end of the tendon of the biceps. It crosses the musculo-cutaneous nerve and passes up the lateral bicipital groove.

The **median basilic vein,** generally shorter but of larger caliber than the median cephalic, extends medially in front of the bicipital fascia (*lacertus fibrosus*) to the medial bicipital groove, taking a more transverse course than the latter vein. It joins the common ulnar vein to form the basilic vein shortly after the formation of the latter by the junction of the anterior and posterior ulnar veins. It crosses the brachial artery, from which it is separated by the bicipital fascia (*lacertus fibrosus*). Branches of the internal cutaneous nerve (*medial cutaneous nerve of forearm*) pass in front of and behind the median basilic vein.

The median basilic is often called the vein of phlebotomy and transfusion, because of its large size, its prominence, and its comparatively fixed relations, but from an anatomic standpoint it is not so safe as the median cephalic because of its more intimate relation with the brachial artery. The operator must always keep the anatomy of this region in mind so as to avoid the possibility of varicose aneurysm or aneurysmal varix. If the blood does not flow freely the patient should be made to grasp an object and to move the fingers. This produces compression of the deep veins and causes the blood to flow into the superficial veins through the median profunda and the other veins that connect the superficial and the deep veins. The veins are made more prominent by compressing them to the proximal side.

PLATE CL.

SUPERFICIAL LYMPHATICS AND GLANDS OF FRONT OF ARM.

The basilic vein is much larger than the cephalic, and passes proximally in front of the medial margin of the biceps to pierce the deep fascia at the junction of the distal and the intermediate thirds of the arm. It passes proximally along the medial side of the brachial artery to become the axillary vein at the lower border of the tendon of the teres major muscle.

Lymphatics (Plate CL).—Lymph glands are generally found at the elbow, sometimes two or three in front and one or two near the distal end of the basilic vein and the medial condyle. Special interest attaches to the lymph glands because in infected wounds of the hand they become swollen and inflamed. The gland (or glands) above the medial condyle (*epicondyle*), known as the epitrochlear, is often found enlarged in early syphilis and in infections of the fingers or hand, as it is the lowest gland in the upper extremity.

The **superficial lymphatics,** beginning below the elbow and formed by the junction of the lymphatics from the radial and ulnar side of the front of the forearm, pass along the medial side of the arm with the basilic vein to enter the axillary glands. A few of those on the radial side of the forearm pass up the lateral side of the arm with the cephalic vein and, crossing the biceps in its proximal part, join the axillary glands; one or two lymph vessels usually continue with the cephalic vein through the delto-pectoral triangle to enter the subclavian glands. *The deep lymphatics* follow the course of the arteries.

Dissection.—Reflect the superficial fascia in the same manner in which the skin was reflected, and study the superficial veins and nerves. These structures can be more conveniently followed through the under surface of the fascia.

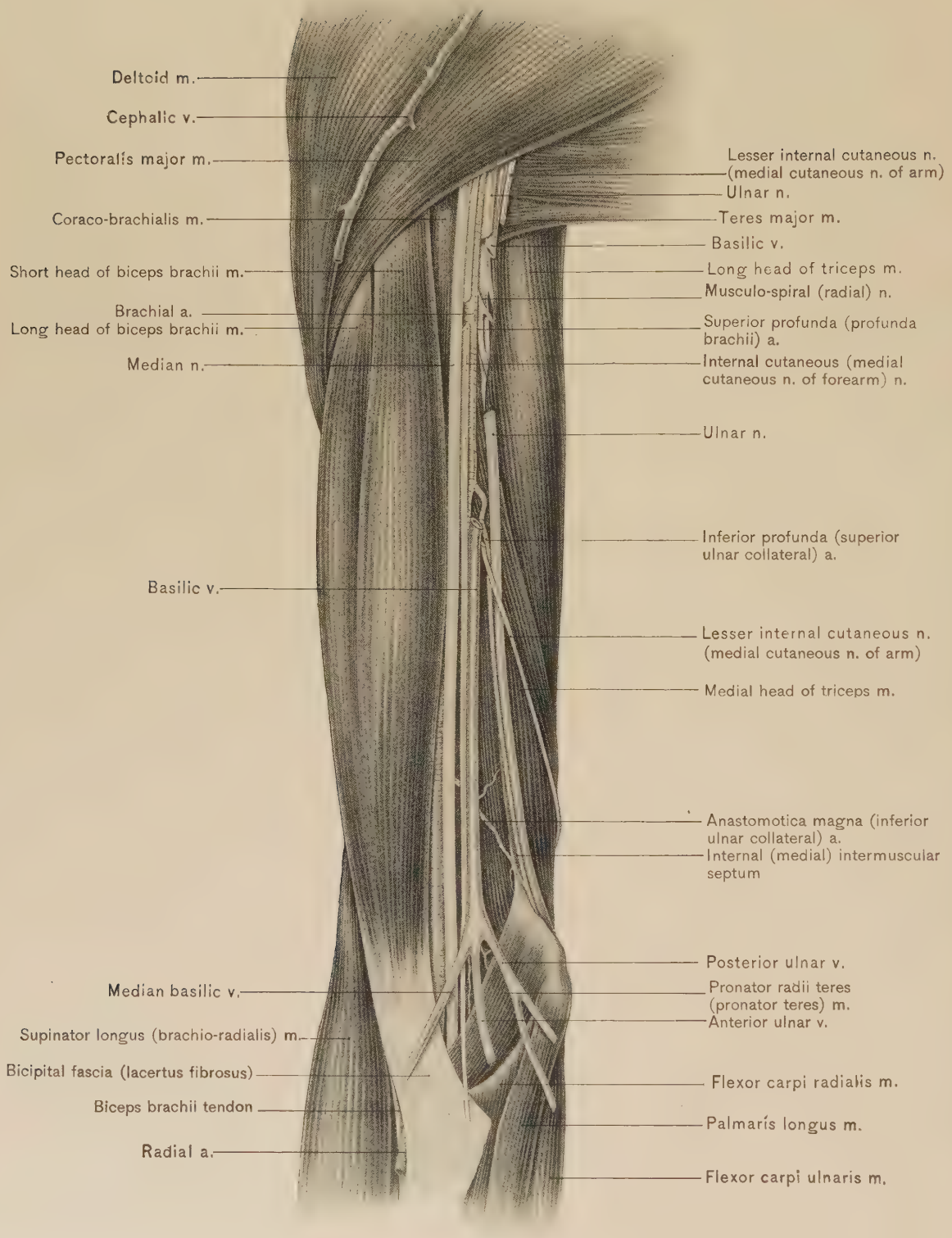
Deep fascia.—The removal of the superficial fascia exposes the deep fascia, which is fibrous in structure and is continuous with its adjacent counterparts of the shoulder, back, chest, and forearm. It is attached above to the anterior edge of the clavicle and to the lateral and inferior edges of the acromion process and the spine of the scapula. Passing distally, it envelops the muscles and other deep structures of the arm, and below the tendon of the triceps muscle is attached to the bony prominences of the elbow-joint, the olecranon, and the condyles (*epicondyles*), whence it continues distally as the general investiture of the forearm. In addition to enveloping the muscles by means of sheaths, it forms partitions between them, two of which, one on either side of the arm, are known as the medial and lateral *intermusclar septa.* This fascia varies in thickness, being thickest over the triceps and the condyles (*epicondyles*) of the humerus, thinnest in front of the biceps, and of medium thickness upon the medial side of the arm, where it serves to cover and protect the main vessels and nerves. Medially, it is reinforced by accessory fibers from the tendons of the pectoralis major and the latissimus dorsi, and laterally, by fibers from the tendon of the deltoid.

The **intermuscular septa.**—The medial intermuscular septum is attached to the medial condyloid (*medial epicondylic*) ridge, and extends from the insertion of the coraco-brachialis to the medial condyle (*epicondyle*) of the humerus. It blends with the tendon of the coraco-brachialis, and gives attachment to the triceps behind, and the brachialis and the pronator teres in front. In the middle of the arm it is perforated by the ulnar nerve and the inferior profunda (*superior ulnar collateral*) artery, and below by the anastomotica magna (*inferior ulnar collateral*) artery. The lateral intermuscular septum is attached to the external condyloid (*lateral epicondylic*) ridge, and extends from the insertion of the deltoid to the lateral condyle (*epicondyle*) of the humerus. It blends with the tendon of the deltoid, and gives attachment to the triceps behind, and to the brachialis, the supinator longus (*brachio-radialis*) and the extensor carpi radialis longus in front. It is perforated below the middle of the arm by the musculo-spiral (*radial*) nerve and the superior profunda (*profunda brachii*) artery.

The intermuscular septa, together with the bone, divide the distal half of the arm into *two osteo-fascial compartments:* an anterior (*volar*) and a posterior (*dorsal*). In the *anterior compartment* are found the biceps, the brachialis, and the origins of the supinator longus (*brachio-radialis*) and the extensor carpi radialis longus, the brachial vessels, the basilic vein, the anastomotica magna (*inferior ulnar collateral*), the inferior profunda (*superior ulnar collateral*) and the termination of the superior profunda (*profunda brachii*), the radial recurrent, and anterior ulnar recurrent arteries, the median, ulnar, medial cutaneous (*medial cutaneous nerve of forearm*) and musculo-cutaneous nerves, and the lower part of the musculo-spiral (*radial*) nerve. In the *posterior compartment* are the triceps muscle, the musculo-spiral (*radial*) nerve, the superior profunda (*profunda brachii*) artery, and the anastomotica magna (*inferior collateral ulnar*) artery.

Dissection.—Divide the deep fascia in the median line of the front of the arm and reflect it laterally, exposing to view the structures which lie in the anterior part of the arm. In reflecting the fascia from the medial side of the arm it is best to sever the medial intermuscular septum, taking care, however, not to injure the structures that pierce it. This will expose the biceps anteriorly; the coraco-brachialis, the brachialis, and the triceps on the medial side; the deltoid, the brachialis, and the origins of the supinator longus (*brachio-radialis*) and the extensor carpi radialis longus on the lateral side. The sulcus upon the medial side of the arm, between the biceps brachii in front and the triceps and brachialis behind, contains the principal vessels and nerves. Before proceeding further with the dissection the student should carefully examine the relations of the brachial vessels with the coraco-brachialis and biceps brachii muscles and the

PLATE CLI.


Deltoid m.
Cephalic v.
Pectoralis major m.
Coraco-brachialis m.
Short head of biceps brachii m.
Brachial a.
Long head of biceps brachii m.
Median n.
Basilic v.
Median basilic v.
Supinator longus (brachio-radialis) m.
Bicipital fascia (lacertus fibrosus)
Biceps brachii tendon
Radial a.
Lesser internal cutaneous n. (medial cutaneous n. of arm)
Ulnar n.
Teres major m.
Basilic v.
Long head of triceps m.
Musculo-spiral (radial) n.
Superior profunda (profunda brachii) a.
Internal cutaneous (medial cutaneous n. of forearm) n.
Ulnar n.
Inferior profunda (superior ulnar collateral) a.
Lesser internal cutaneous n. (medial cutaneous n. of arm)
Medial head of triceps m.
Anastomotica magna (inferior ulnar collateral) a.
Internal (medial) intermuscular septum
Posterior ulnar v.
Pronator radii teres (pronator teres) m.
Anterior ulnar v.
Flexor carpi radialis m.
Palmaris longus m.
Flexor carpi ulnaris m.

BRACHIAL ARTERY AND BICEPS BRACHII MUSCLE.

median nerve which accompanies the vessels, since the relations of these structures are somewhat altered by cleaning.

The **brachial artery** (Plate CLI), the continuation of the axillary, begins opposite the lower border of the tendon of the teres major. It passes down the ulnar side of the arm, being overlapped for fully two-thirds of its course by the medial border of the coraco-brachialis and biceps brachii muscles. It then curves medialward in front of the elbow-joint, along the medial border of the tendon of the biceps, to a point opposite the neck of the radius, two centimeters (seven-eighths of an inch) below the crease of the elbow, where it divides into the *radial* and *ulnar arteries*. Its course is quite accurately indicated by a line drawn from the junction of the anterior and the middle third of the lateral wall of the axilla, to the middle of the front of the elbow-joint. It should be remembered that quite frequently the brachial artery bifurcates some distance above the usual point, the two vessels then running side by side.

Relations of the Brachial Artery.—From above downward, upon its lateral side, are the coraco-brachialis and the biceps brachii, which, as already stated, slightly overlap the artery. When the biceps brachii arises by three heads, the proximal portion of the artery lies beneath the most medial head. The median nerve, for about two and a half centimeters (one inch), also lies on the lateral side in the groove between the artery and the coraco-brachialis. In front of the artery are the skin and the fasciæ; the medial borders of the coraco-brachialis and the biceps in the proximal two-thirds of its course, the median nerve in the intermediate third, and the bicipital fascia (*lacertus fibrosus*) and the median basilic vein below; on the medial side are the ulnar nerve in the proximal half of its course, the internal cutaneous nerve (*medial cutaneous nerve of forearm*) and the basilic vein in the proximal two-thirds of its course, and the median nerve in the distal third; behind are the musculo-spiral (*radial*) nerve and the superior profunda (*profunda brachii*) artery, the long and medial heads of the triceps in the proximal part of the arm, the insertions of the coraco-brachialis in the middle, and the brachialis in the distal part of the arm. Throughout its course it is flanked by two closely adjacent accompanying veins (venæ comites), connected with each other by occasional transverse veins.

The artery is comparatively superficial throughout its entire extent, being covered by skin and superficial and deep fascia, except in the middle of its course, where the median nerve lies in front, and at its distal end, where the bicipital fascia (*lacertus fibrosus*) and the median basilic vein are in front of it. It is most readily compressed in the middle of the arm, where it rests upon the insertion of the coraco-brachialis, the most suitable point for compressing the artery with

the pad of the tourniquet in amputation of the forearm. Pressure should be directed lateralward and backward.

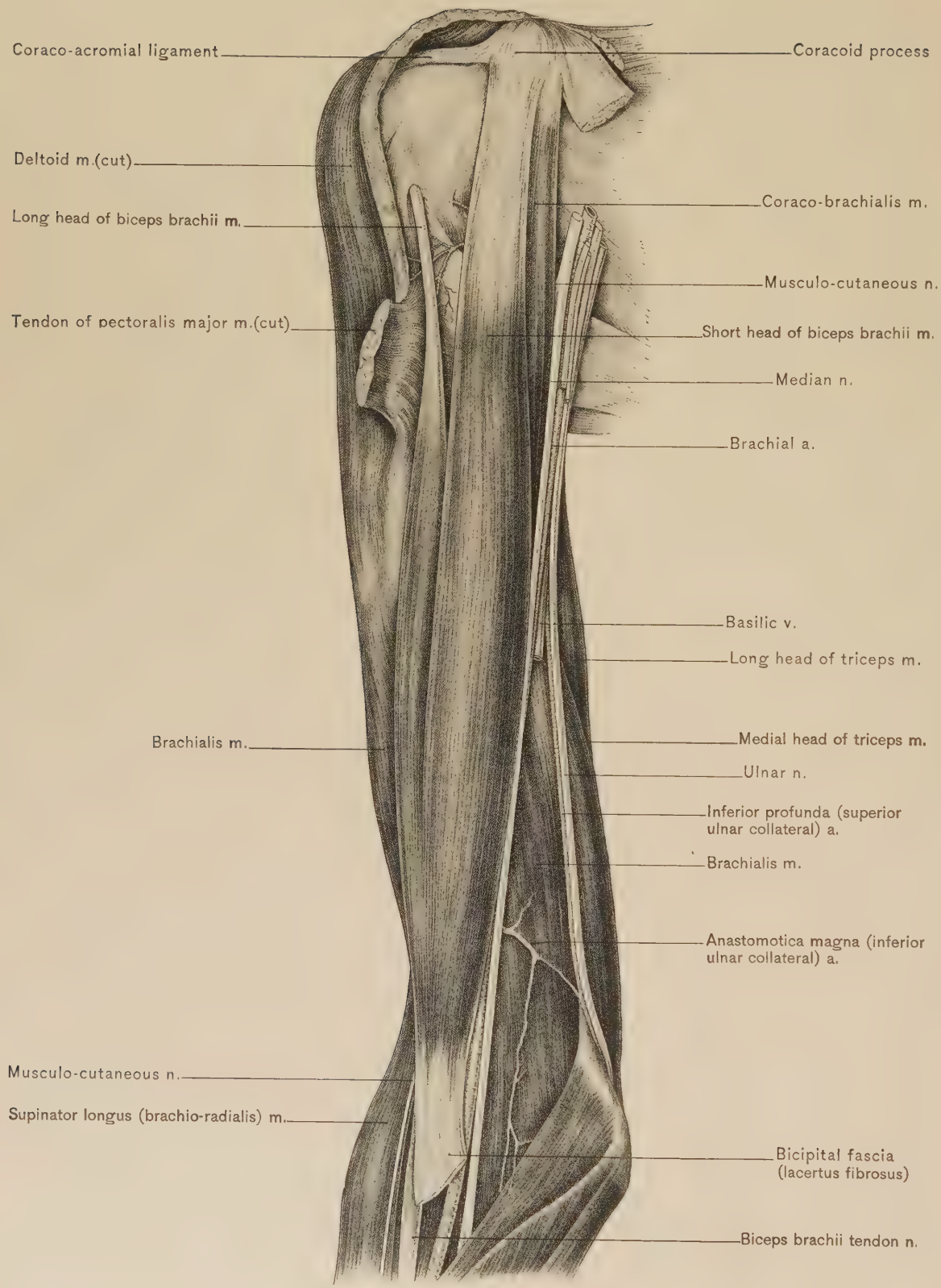
The *branches of the brachial artery* are: the superior profunda (*profunda brachii*) and the inferior profunda (*superior ulnar collateral*), the nutrient, the anastomotica magna (*inferior ulnar collateral*), the muscular, and occasionally vasa aberrantia.

The **superior profunda** (**profunda brachii**) **artery,** the largest branch, arises from the medial and dorsal aspect of the upper end of the brachial and, turning backward, enters the musculo-spiral (*radial*) groove with the musculo-spiral (*radial*) nerve. In the groove it passes behind the humerus, between the medial and the lateral heads of the triceps to the radial side of the arm, pierces the lateral intermuscular septum, and continues downward between the brachialis and the supinator longus (*brachio-radialis*) muscles to the elbow, where it anastomoses with the radial recurrent. In its course it sends branches to supply the deltoid, the coraco-brachialis, and the triceps muscles, and one branch to anastomose with the circumflex arteries. This branch plays an important part in the collateral circulation after ligation of the main vessel in this locality. It gives off a large *posterior articular* branch (in reality the continuation of the artery) which passes straight down the humerus from the musculo-spiral (*radial*) groove to the back of the elbow-joint, accompanied by the branch of the musculo-spiral (*radial*) nerve supplying the anconeus muscle, and anastomoses with the interosseous recurrent, the anastomotica magna (*inferior ulnar collateral*), and the posterior ulnar arteries, and assists in forming the rete olecrani.

The **inferior profunda** (**superior ulnar collateral**) **artery** is a small vessel which arises from the brachial near the insertion of the coraco-brachialis, and passes downward and medialward on the surface of the medial head of the triceps. It pierces the medial intermuscular septum and accompanies the ulnar nerve between the medial condyle (*epicondyle*) and the olecranon, where it anastomoses with the posterior ulnar recurrent and the anastomotica magna (*inferior ulnar collateral*). In front of the medial condyle (*epicondyle*) it also sends downward a small branch which anastomoses with the anterior ulnar recurrent and the anastomotica magna (*inferior ulnar collateral*). Sometimes it arises with the superior profunda (*profunda brachii*) by a common trunk.

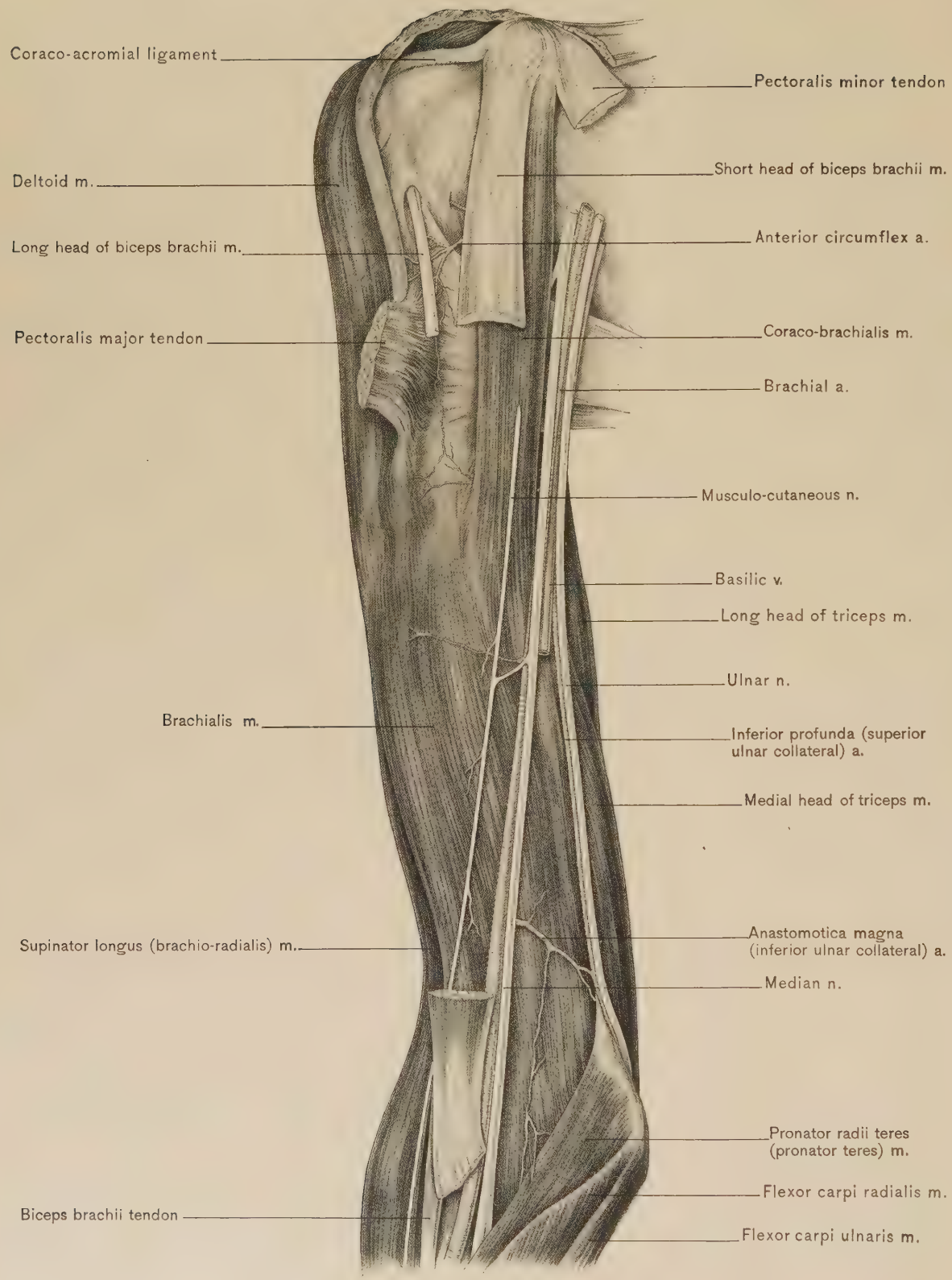
The **nutrient artery** leaves the brachial in the middle of the arm, or is derived from one of its muscular branches and, passing downward, pierces the tendon of the coraco-brachialis to enter the nutrient canal of the humerus below the insertion of that muscle, where it divides into ascending and descending branches which anastomose with the nutrient vessels of the periosteum. Sometimes it arises from the superior profunda (*profunda brachii*). Entering the bone with it

PLATE CLII.



BICEPS BRACHII MUSCLE.

PLATE CLIII.



VIEW OF ARM,—BICEPS BRACHII REMOVED.

is a filament of the musculo-cutaneous nerve. When this artery is injured in fracture of the humerus union may be slow.

The **anastomotica magna (inferior ulnar collateral) artery** is given off about six centimeters (two and a half inches) above the elbow, whence it passes medialward over the brachialis and pierces the medial intermuscular septum. It then winds around the humerus between the triceps and the bone, and anastomoses above the olecranon with the posterior articular branch of the superior profunda (*profunda brachii*) and the interosseous recurrent. In its passage across the brachialis it gives off an anastomotic branch which also pierces the medial intermuscular septum to join the posterior ulnar recurrent, between the olecranon and the medial condyle (*epicondyle*). Ascending and descending branches are also given off to join the inferior profunda (*superior ulnar collateral*) above, and the anterior ulnar recurrent in front of the medial condyle (*epicondyle*).

Muscular branches arise from the lateral side of the brachial artery and supply the coraco-brachialis, the biceps, and the brachialis muscles.

Vasa aberrantia are long, narrow arteries which are occasionally found connecting the brachial or the axillary artery with some of the main arteries of the forearm, usually the radial. The vasa aberrantia, together with the liberal anastomosis around the elbow-joint, are of surgical importance since they offer channels for collateral circulation of the blood in case its flow through the radial, the ulnar, or the lower part of the brachial arteries is prevented.

The **muscles in the front of the arm** are the biceps, the coraco-brachialis, and the brachialis.

The **biceps brachii** (Plates CLII; CLIII), the largest and most prominent muscle of this group, arises by two tendinous heads, the long and the short head. The *long head of the biceps brachii arises* by a tendon from the upper border of the glenoid cavity of the scapula, being continuous with the glenoid ligaments (*labrum glenoidale*), by means of which it is united with the long head of the triceps, which arises from the lower border of the same cavity. The tendon of the long head passes through a sheath derived from the synovial sac of the shoulder-joint, in which it arches over the head of the humerus. It emerges from the capsule between the two tuberosities and passes down the bicipital groove (*intertubercular sulcus*) in which it is retained by an aponeurosis derived from the tendon of the pectoralis major, being covered by its synovial sheath for about five centimeters (two inches) in the upper part of the groove. Shortly after leaving the groove this head becomes muscular. It is through the perforation in the capsule that pus in the shoulder-joint may find an exit. The pus follows the tendon, passes under the transverse humeral ligament, then under the tendon of the pectoralis major, appearing on the lower border of the anterior aspect of the arm.

The tendon may be luxated; this always occurs medially. It may also be ruptured by violent muscular contraction.

The *short head of the biceps brachii arises* by a flattened tendon from the tip of the coracoid process of the scapula in common with the coraco-brachialis, whence it passes downward and slightly lateralward to join the long head opposite the middle of the humerus. The biceps ends abruptly below in a flattened tendon, which, after giving off an aponeurotic expansion, the bicipital aponeurosis (*lacertus fibrosus*), from its medial side, becomes twisted upon itself, and is *inserted* into the posterior edge of the tuberosity of the radius (Plate CLIV). A synovial sac intervenes between the tendon and the anterior part of the tuberosity. The bicipital fascia (*lacertus fibrosus*) passes medialward over the brachial artery and beneath the median basilic vein and blends with the deep fascia of the forearm. The relation of the brachial artery to the bicipital fascia (*lacertus fibrosus*) and the median basilic vein is of interest because, inexplicable as such an accident may seem, it has happened that the artery, as well as the vein, has been opened in venesection, resulting in an arterio-venous aneurysm. The two bellies of the biceps muscle are united by connective tissue almost as far as the tendon, near which their fibers interdigitate before their attachment to the front of this structure. The biceps, in its proximal part, rests upon the musculo-cutaneous nerve, which passes obliquely behind it, and against the humerus; in its distal half it lies upon the brachialis. Its tendon occupies the triangular space in front of the elbow, the brachial artery being on its medial side. On the medial side of the muscle are the coraco-brachialis muscle, the brachial vessels, and the median nerve. Its proximal end is covered by the tendon of the pectoralis major and the anterior edge of the deltoid. For the remainder of its course it is subcutaneous and readily discernible.

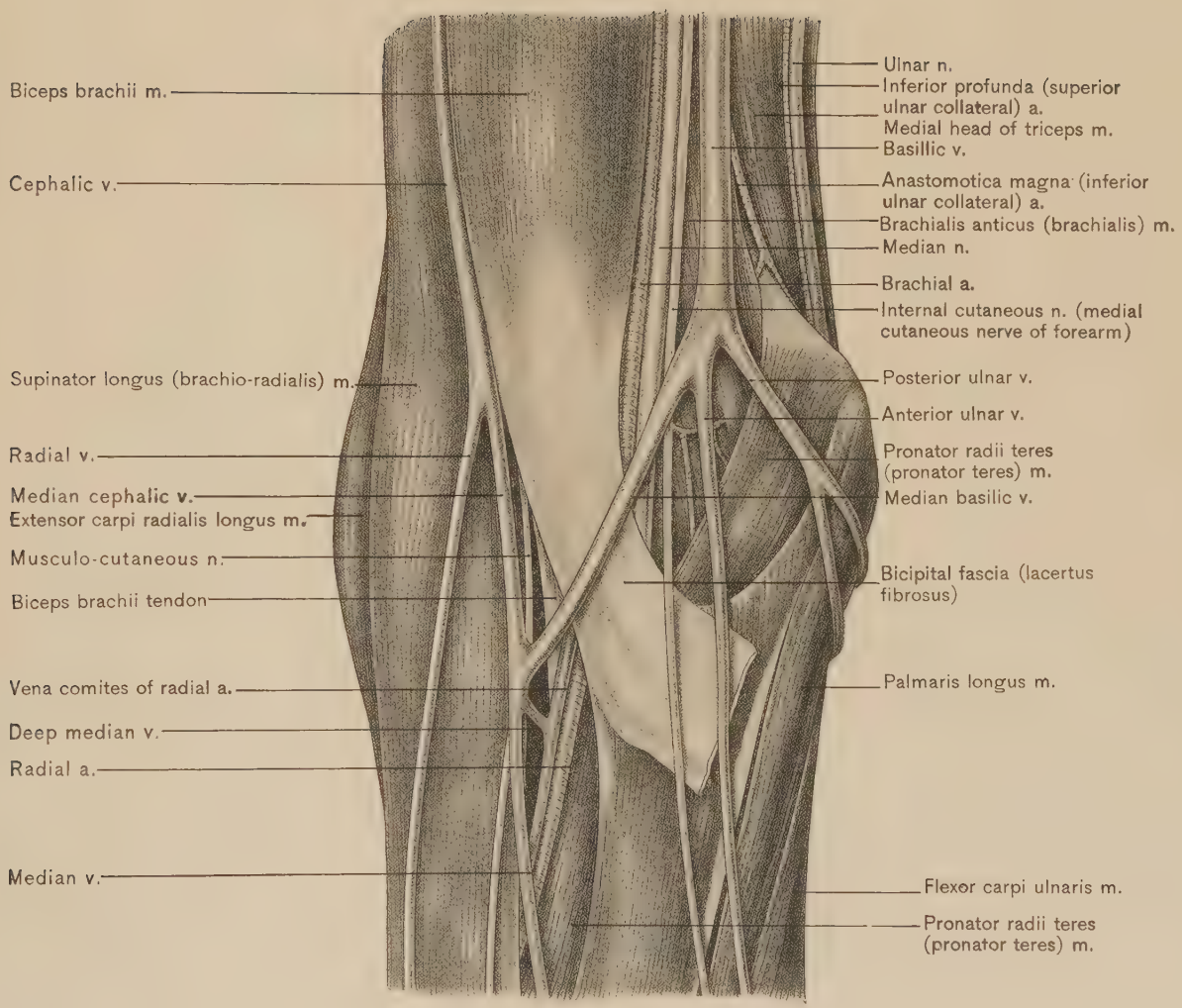
Occasionally, between the coraco-brachialis and the brachialis, there arises from the medial side of the humerus an accessory head which, in its course toward the bicipital fascia (*lacertus fibrosus*) for insertion, assumes varying relations with the brachial artery, either crossing in front of or behind the artery, or dividing to permit this vessel to pass through it. In ligating the brachial artery an accessory muscular head, when present, may be severed without hesitation.

Blood Supply.—From the muscular branches of the brachial artery.

Nerve Supply.—From the musculo-cutaneous nerve.

Action.—The function of the biceps is to flex the forearm on the arm, to supinate the forearm, and slightly to adduct the arm. It is also well to bear in mind that in spite of its intimate anatomic and functional relations to the bone, in no part of its course is the biceps muscle normally attached to any part of the humerus.

PLATE CLIV.



BICIPITAL FASCIA (LACERTUS FIBROSUS) AND VESSELS AND NERVES AT ELBOW.

The **coraco-brachialis** is a slender **muscle,** *arising* conjointly with the short head of the biceps brachii, and extending from the tip of the coracoid process to the middle of the medial side of the humerus, where it is *inserted* into a rough impression between the attachment of the medial head of the triceps and the brachialis just above the foramen for the nutrient artery to the bone and opposite the insertion of the deltoid. Proximally, it is hidden by the pectoralis major and the deltoid; it then becomes superficial as far as its insertion, where it is crossed by the brachial vessels and the median nerve. The proximal portion of the muscle acts as a guide to the axillary artery, and against the flat tendon of insertion the brachial artery can be compressed. The pain caused by a tourniquet at this site is due to the simultaneous pressure on the median nerve. Laterally, the muscle lies in contact with the short head of the biceps.

Blood Supply. —Chiefly from the brachial artery.

Nerve Supply.—From the musculo-cutaneous nerve which pierces it obliquely.

Action.—It draws the arm forward and medially.

The **brachialis muscle** *arises* from the humerus by two fleshy digitations on either side of the insertion of the deltoid, and from the front and the medial side of the shaft of the bone below this point, as well as from the lateral and medial intermuscular septa. It is a broad, flat muscle, which covers the distal half of the front of the humerus and the anterior ligament of the elbow-joint, to which it is closely attached. It ends in a short tendon, which is *inserted* into the front of the base of the coronoid process of the ulna where it bears the same relation to the two digitations of the flexor digitorum profundus as does its origin to the insertion of the deltoid above. This muscle is covered by the deep fascia on the lateral side and by the biceps, and is crossed by the brachial vessels, the median, the musculo-cutaneous, and musculo-spiral (*radial*) nerves. Laterally, it is related with the musculo-spiral (*radial*) nerve, the superior profunda (*profunda brachii*), and the radial recurrent arteries, the extensor carpi radialis longus and supinator longus (*brachio-radialis*) muscles; medially, it is in contact with the triceps muscle, the ulnar nerve, and the pronator radii teres muscle.

Blood Supply.—From the brachial artery.

Nerve Supply.—From the musculo-cutaneous and the musculo-spiral (*radial*) nerves.

Action.—It flexes the forearm on the arm.

The **Nerves of the Arm** (Plate CXLVI) proceed from the brachial plexus. They are: the musculo-cutaneous from the lateral cord; the median from the medial and lateral cords; the ulnar, the internal cutaneous (*medial cutaneous nerve of forearm*), and the lesser internal cutaneous (*medial cutaneous nerve of arm*) from

the medial cord; the circumflex (*axillary*) and musculo-spiral (*radial*) from the posterior cord. The ramifications of these nerves in the superficial fascia have been fully described, and the course of the main trunks has been mentioned. Of the larger nerves, the median and the ulnar pass down the medial side of the arm; the circumflex (*axillary*) and the musculo-spiral (*radial*) curve behind the humerus to the lateral side of the arm; the musculo-cutaneous crosses the front of the arm to the lateral side of the forearm. Of these, the circumflex (*axillary*) is the only one which has ascending branches.

The **musculo-cutaneous nerve,** arising from the lateral cord of the brachial plexus, in common with the lateral head of the median nerve at the lateral side of the axillary artery, opposite the lower margin of the pectoralis minor, at once enters the coraco-brachialis muscle, through which it passes distally and lateralward, thence between the biceps and the brachialis to the lateral side of the arm a little above the elbow, where it pierces the deep fascia. It supplies the coraco-brachialis, the biceps, and the brachialis muscles, the humerus, and the elbow-joint. At the elbow it passes beneath the median cephalic vein and divides into an anterior and a posterior branch. The anterior branch communicates with the radial (*superficial branch of the radial*) nerve and ends in the skin over the thenar eminence; the posterior branch supplies the skin as far as the wrist. Loss of power of elbow flexion, associated with numbness or anesthesia of the radial side of the forearm, indicates an affection of this nerve.

The **median nerve** is formed by two fasciculi, or nerve strands, one from the lateral, and the other from the medial cord of the brachial plexus. The two heads, known as the lateral and the medial heads, lie on opposite sides of the third portion of the axillary artery and unite, either in front of it, or on its lateral side, in a **Y**, the stem of which is the median nerve. In its course along the medial side of the arm the median nerve hugs the brachial artery, being generally upon the lateral side of it in its proximal part, then gradually moving medialward to rest in front of it in the middle of the arm, and continuing medialward so that in the distal third of the arm it lies upon the medial side of this vessel. At the distal end of the arm it is covered by the bicipital fascia (*lacertus fibrosus*), and is crossed by the median basilic vein. It gives off muscular branches and also the anterior (*volar*) interosseous nerve, and continues downward to the palm. In the middle of the arm the median nerve is occasionally found behind the brachial artery instead of in front of it.

The **ulnar nerve,** in common with the medial head of the median nerve, arises from the medial cord of the brachial plexus. It passes distally along the medial side of the axillary and brachial arteries, diverging medially from the latter at the middle of the arm opposite the insertion of the coraco-brachialis

muscle. It then crosses the medial head of the triceps and, accompanied by the inferior profunda (*superior ulnar collateral*) artery, pierces the medial intermuscular septum, fourteen centimeters (five and a half inches) above the elbow, to enter the groove between the olecranon and the medial condyle (*epicondyle*). Trauma of the nerve at this point is frequent, and is followed by a tingling sensation felt at its distribution to the little and the ring fingers, whence it derives the name, "funny bone." The ulnar nerve holds so close a relation to the posterior surface of the medial condyle (*epicondyle*) that, in fracture of the latter, a fragment or callus may press upon the nerve and produce tingling or numbness of the ulnar side of the forearm and hand, the little finger, and the ulnar side of the ring finger, and spasm or paralysis of the muscles supplied by this nerve. These muscles are: the flexor carpi ulnaris, the ulnar side of the flexor digitorum profundus, the palmaris brevis, the muscles of the hypothenar eminence, the interossei, the two ulnar lumbricales, the adductor pollicis, and the medial head of the flexor pollicis brevis.

The **internal cutaneous nerve** (**medial cutaneous nerve of forearm**) arises from the medial cord of the brachial plexus, passes distally beneath the deep fascia along the medial side of the axillary and brachial arteries, between the latter and the ulnar nerve, and divides a little below the middle of the arm, after piercing the hiatus semilunaris, which also admits the basilic vein, into an anterior (*volar*) and a posterior (*ulnar*) branch. The anterior (*volar*) branch enters the forearm either in front of, or behind the median basilic vein and supplies the skin of the forearm as far as the wrist; the posterior (*ulnar*) branch descends along the medial side of the basilic vein to enter the forearm behind the medial condyle (*epicondyle*). Before it divides, the nerve gives off a cutaneous branch which pierces the deep fascia and supplies the skin of the anterior and medial side of the arm almost as far as the elbow.

The **lesser internal cutaneous nerve** (**medial cutaneous nerve of arm**), or nerve of Wrisberg, arises from the medial cord of the brachial plexus above the origin of the internal cutaneous nerve (*medial cutaneous nerve of forearm*), from which point it passes behind the axillary vein, and then on the medial side of the vein, where it communicates with the posterior division of the lateral cutaneous branch of the second intercostal nerve, the intercosto-humeral (*intercosto-brachial*). The nerve then passes distally to the middle of the arm, where it pierces the deep fascia, and is distributed to the skin over the distal third of the dorsum of the arm, as well as the medial condyle (*epicondyle*) and the olecranon, and communicates with the posterior branch of the internal cutaneous nerve (*medial cutaneous nerve of forearm*).

The **circumflex (axillary) nerve** arises, with the musculo-spiral (*radial*), from the posterior cord of the brachial plexus. It descends in front of the subscapularis muscle behind the axillary artery, and turns backward at the lower margin of the muscle, giving off an articular branch which enters the shoulder-joint below the subscapularis. Here it divides into an upper and a lower branch. The upper branch, accompanied by the posterior circumflex vessels, curves behind the surgical neck of the humerus and under the deltoid to its anterior border, giving off filaments to supply the muscle and the skin covering it. The lower branch sends a filament, usually containing a gangliform enlargement, to the teres minor muscle, and one or more branches to the posterior portion of the deltoid; it then pierces the deep fascia to supply the skin over the long head of the triceps and the distal two-thirds of the posterior portion of the deltoid. Injury to this nerve causes tingling or partial anesthesia of the skin over the deltoid, and muscular twitching or paralysis of the deltoid and the teres minor muscles.

The **musculo-spiral (radial) nerve** is the continuation of the posterior cord, and is the largest branch of the brachial plexus. It passes downward behind the axillary vessels and in front of the tendons of the latissimus dorsi and teres major muscles. Accompanied by the superior profunda (*profunda brachii*) artery, it passes distally and laterally between the lateral and medial heads of the triceps around the back of the humerus in the musculo-spiral (*radial*) groove to the lateral side of the distal part of the arm, where it pierces the lateral intermuscular septum. Thence it continues distally between the brachialis medially, and the supinator longus (*brachio-radialis*) laterally, both of which it supplies, to the front of the lateral condyle (*epicondyle*), where it divides into the *radial* (*superficial branch of radial*) and the *posterior interosseous nerves*. On the medial side of the arm it gives off *internal muscular branches* to the lateral and medial heads of the triceps; in the musculo-spiral (*radial*) groove it sends branches to the lateral head of the triceps and the anconeus; on the lateral side of the arm it gives off lateral branches to the supinator longus (*brachio-radialis*), extensor carpi radialis longus, and brachialis muscles. A small *internal cutaneous branch* (*posterior cutaneous nerve of arm*) arises in the axilla, pierces the deep fascia in the upper part of the arm, and passes to the skin of the medial side and back of the arm almost as far as the olecranon. A *superior external cutaneous branch* of the posterior external cutaneous nerve (*proximal branch of dorsal cutaneous nerve of forearm*) perforates the lateral head of the triceps close to the humerus, then pierces the deep fascia and accompanies the cephalic vein to the front of the elbow, supplying the skin of the distal half of the front of the arm. An *inferior external cutaneous branch* of the same nerve (*distal branch of dorsal cutaneous nerve of forearm*) also goes through the lateral head of the triceps with the preceding branch, then

pierces the deep fascia near the insertion of the deltoid, and passes distally to be distributed to the skin on the lateral side of the distal half of the arm, the elbow, and the radial and dorsal part of the forearm, communicating near its termination with the posterior branch of the musculo-cutaneous nerve. It is interesting to note that the musculo-spiral (*radial*) nerve supplies all the extensor and all the supinator muscles except the biceps. (Incisions for exposure of the musculo-spiral (*radial*) nerve are shown in Plates CCVI and CCVII.)

Since the musculo-spiral (*radial*) nerve lies in contact with the back of the shaft of the humerus, paralysis of this nerve above the insertion of the deltoid, whether resulting from fracture of the humerus or from pressure, as from sleeping on the arm or the use of crutches, or from lead poisoning or overstretching of the nerve, results in "wrist drop" and pronation of the forearm. Paralysis after a fracture is due to one of three causes: (1) injury to the nerve at the time of fracture; (2) stretching the nerve over the sharp edge of a fragment; (3) inclusion in the callus.

THE FRONT OF THE FOREARM

Dissection.—Extend the forearm and hand so that the structures in this region are tense. Continue the incision made along the lateral side of the arm down the radial side of the forearm to the tip of the styloid process of the radius. From the latter point carry a transverse incision across the front of the wrist. Reflect the skin from without medialward, and expose the superficial fascia and the superficial veins. The skin being thin can be raised in folds, and allows the superficial veins to be seen beneath it.

In the superficial fascia are found: the radial, anterior ulnar, and median veins, and the musculo-cutaneous nerve, the anterior branch of the internal cutaneous nerve (*medial cutaneous nerve of forearm*), a cutaneous branch of the ulnar and of the median nerve, branches of the radial and ulnar arteries, and the superficial lymphatics.

The **radial vein** (Plate CXLIX) appears upon the front of the radial side of the forearm above its distal third, where it winds forward and proximally on the radial side of the forearm (generally superficial to the cutaneous nerve) to form the *cephalic vein* at the elbow by junction with the median cephalic. It arises from the radial side of the dorsal venous arch of the hand, receives radicles from the back of the thumb and the second finger, and communicates with the median vein. This vein is sometimes described differently by other authors.

The **anterior ulnar vein** passes proximally along the ulnar side of the forearm to within a short distance of the elbow, where it joins the posterior ulnar to form the *common ulnar*, which in turn almost immediately unites with the median

basilic to form the *basilic vein*. It is formed by radicles at the wrist, and communicates with the median and posterior ulnar veins.

The **median vein** begins at, or a little above the wrist and runs up the middle of the forearm. It collects blood from the palm of the hand and the front of the forearm, and communicates freely with the radial and anterior ulnar veins. Upon reaching the bend of the elbow, it communicates with the venæ comites of the radial and ulnar arteries by means of the deep median (*profunda*) vein, a large distinct vein, and at once divides into two branches, the median cephalic and the median basilic.

The **musculo-cutaneous nerve** (Plate CLIII) becomes superficial a short distance proximal to the elbow on the lateral side of the tendon of the biceps, and passes distally upon the radial side of the front of the forearm, ending upon the ball of the thumb (thenar eminence). Just distal to the elbow, it gives off a posterior branch which supplies the radial side of the back of the forearm. Its anterior branch, the continuation of the musculo-cutaneous, lies in front of the radial artery in the distal part of the forearm and communicates with a branch of the radial nerve (*superficial branch of the radial*). It terminates in filaments to the skin over the ball of the thumb.

The **anterior branch of the internal cutaneous nerve** (**volar branch of the medial cutaneous nerve of forearm**) enters the forearm at the ulnar side of the front of the elbow, either in front of, or behind the median basilic vein; thence it continues downward upon the ulnar side of the front of the forearm, supplying the skin on its way to the wrist, where it communicates with a branch of the ulnar nerve.

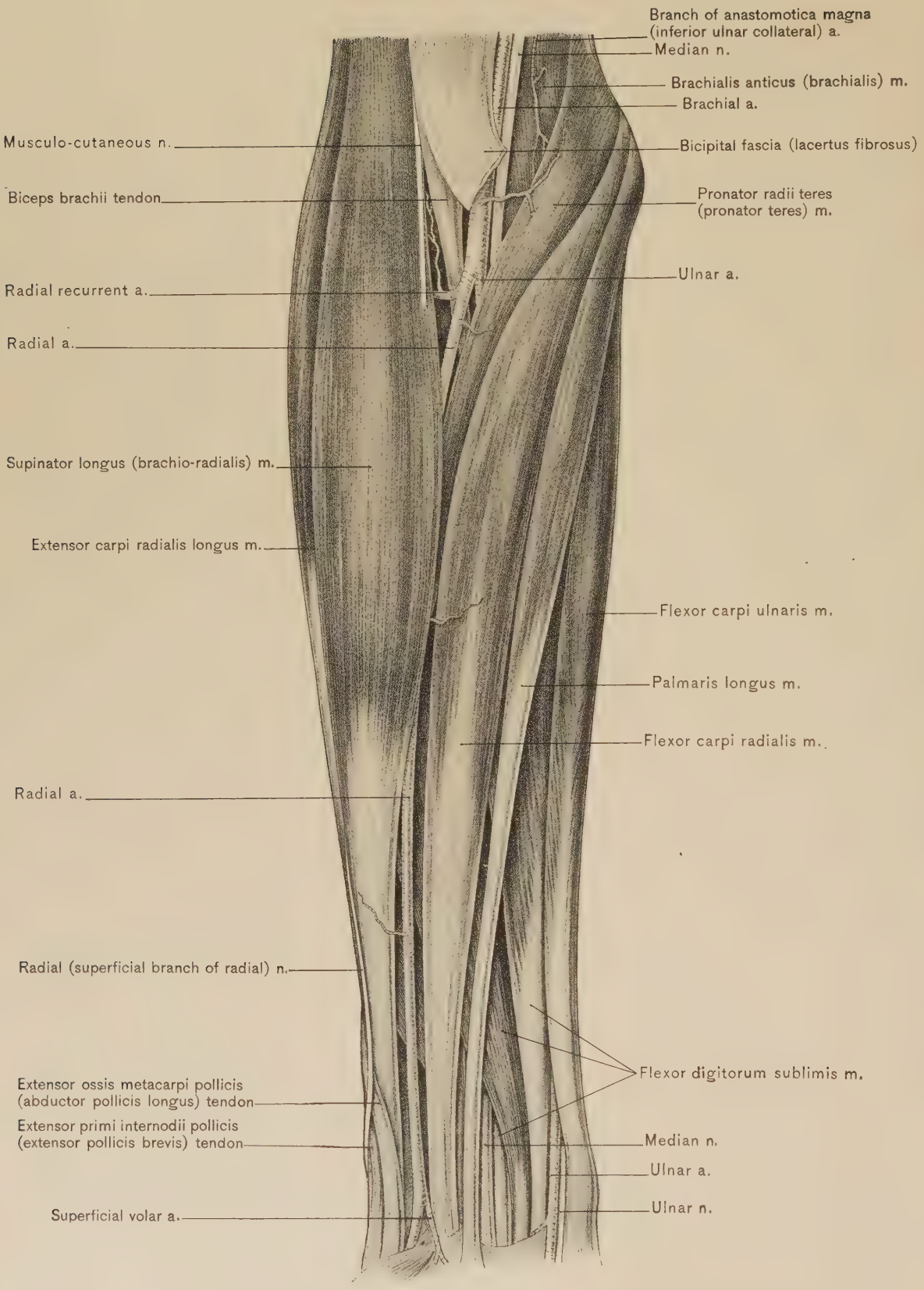
A **cutaneous branch of the ulnar nerve** is found coming through the deep fascia about ten centimeters (four inches) above the wrist near the tendon of the flexor carpi ulnaris.

A **cutaneous branch of the median nerve** pierces the deep fascia about five centimeters (two inches) above the middle of the wrist and passes to the palm.

The **superficial arteries** of the forearm are small cutaneous branches from the radial and ulnar arteries.

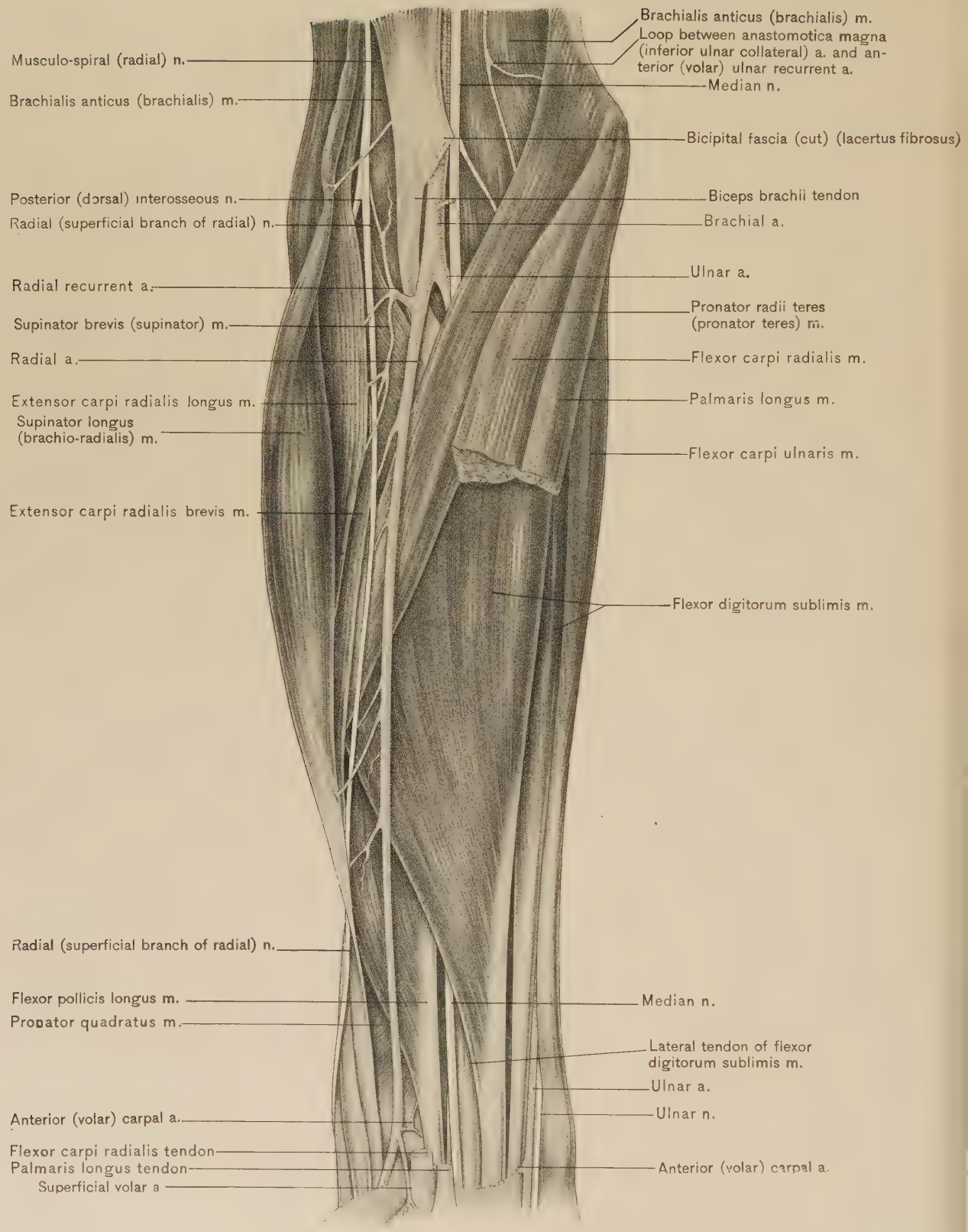
The **superficial lymphatics** accompany the superficial veins, and are more numerous on the ulnar than on the radial side of the forearm. They terminate chiefly in a lymph gland situated above the medial condyle (*epicondyle*). They begin at the ends of the fingers, two on the palmar and two on the dorsal surface. Those on the palmar surface of the fingers join an arch in the palm of the hand, from which arise the vessels which accompany the anterior ulnar, the median, and the radial veins; those on the dorsal aspect of the fingers form a plexus on the back of the hand, from which vessels pass up the back of the forearm and around

PLATE CLV.



TRIANGLE OF ELBOW (ANTE-CUBITAL FOSSA) AND SUPERFICIAL MUSCLES OF FOREARM.

PLATE CLVI.


Brachialis anticus (brachialis) m.
Loop between anastomotica magna (inferior ulnar collateral) a. and anterior (volar) ulnar recurrent a.
Musculo-spiral (radial) n.
Median n.
Brachialis anticus (brachialis) m.
Bicipital fascia (cut) (lacertus fibrosus)
Posterior (dorsal) interosseous n.
Biceps brachii tendon
Radial (superficial branch of radial) n.
Brachial a.
Ulnar a.
Radial recurrent a.
Pronator radii teres (pronator teres) m.
Supinator brevis (supinator) m.
Radial a.
Flexor carpi radialis m.
Extensor carpi radialis longus m.
Palmaris longus m.
Supinator longus (brachio-radialis) m.
Flexor carpi ulnaris m.
Extensor carpi radialis brevis m.
Flexor digitorum sublimis m.
Radial (superficial branch of radial) n.
Flexor pollicis longus m.
Median n.
Pronator quadratus m.
Lateral tendon of flexor digitorum sublimis m.
Ulnar a.
Anterior (volar) carpal a.
Ulnar n.
Flexor carpi radialis tendon
Palmaris longus tendon
Anterior (volar) carpal a.
Superficial volar a

TRIANGLE OF ELBOW (ANTE-CUBITAL FOSSA). FLEXOR DIGITORUM SUBLIMIS MUSCLE, RADIAL ARTERY, AND RADIAL (SUPERFICIAL BRANCH OF RADIAL) NERVE.

either side to empty into those on the volar surface of the forearm. The greater number of these vessels pass proximally on the medial side of the arm with the basilic vein. A few accompany the cephalic vein.

DISSECTION.—Trace the superficial veins in the superficial layer of the superficial fascia and remove this fascia in one flap. Follow the nerves through the under surface of the fascia. The deep fascia is now exposed.

The **deep fascia** of the forearm is continuous with that of the arm, and is composed of circular and oblique white fibers bound together by a few longitudinal fibers. It is attached to the bony prominences of the forearm, and sends prolongations between the muscles, separating them and providing additional surfaces for their origins. It is most dense at the back of the forearm, least dense in front of the proximal part of the forearm, and of medium density above and at the wrist, where it forms the posterior annular (*dorsal carpal*) ligament and is continuous with the anterior annular (*transverse carpal*) ligament. The deep fascia is reinforced by tendinous accessions from the biceps, the bicipital fascia (*lacertus fibrosus*), the brachialis and the triceps muscles. Numerous expanding intermuscular septa at the elbow, beginning at the limited area of the surface of the medial condyle, form cone-shaped aponeurotic spaces for the origins of many muscles. A transverse intermuscular septum divides the muscles of the forearm into a superficial and a deep group. Besides smaller apertures for the passage of cutaneous vessels and nerves, it contains an aperture of considerable size distal to the elbow for the passage of the deep median (*profunda*) vein, which connects the venæ comites of the radial artery with the superficial veins.

DISSECTION.—Remove the deep fascia by incisions corresponding to those used in reflecting the skin and superficial fascia. The removal of the deep fascia at the upper and ulnar part of the forearm is not so easy as in most other regions, owing to its blending with the underlying superficial group of flexor muscles, to which it gives partial origin. It can be removed to better advantage by reflecting it from below upward.

The **triangle at the bend of the elbow, or antecubital (cubital) fossa** (Plates CLV; CLVI) is bounded proximally by an imaginary line drawn between the condyles (*epicondyles*) of the humerus which forms its base; laterally, by the supinator longus (*brachio-radialis*), and medially, by the pronator teres. The apex of the triangle is at the point where the supinator longus (*brachio-radialis*) crosses the pronator teres. Its floor is formed by the brachialis and supinator brevis (*supinator*) muscles, and its roof by the deep fascia. Within this triangle, when its lateral boundaries are displaced, the supinator longus (*brachio-radialis*) lateralward and the pronator teres medialward, the following structures are seen from within outward: the anterior ulnar recurrent artery, the median nerve, the

brachial artery, its venæ comites, the two terminal branches of the brachial or radial and ulnar arteries, their venæ comites, the deep median (*profunda*) vein, the commmon interosseous artery, the tendon of the biceps, the radial recurrent artery, and the musculo-spiral (*radial*) nerve. In rupture of the biceps muscle the tendon can frequently be felt distinctly loose and free and can be manipulated in this space.

The **muscles** of the forearm may be divided into an ulnar, or volar, and a radial, or dorsal, group; the former include the pronators and the flexors; the latter, the supinators and the extensors. The ulnar group *arises* chiefly by a common tendon from the medial condyle (*epicondyle*) and medial epicondylic ridge, and the radial from the lateral condyle (*epicondyle*) and lateral epicondylic ridge.

The **pronator radii teres,** the shortest muscle of the ulnar group, *arises* by two heads: a large, or superficial, and a small, or deep, head. The large, or superficial, head *springs from* the most distal part of the medial epicondylic ridge and the medial condyle (*epicondyle*) of the humerus, an intermuscular septum separating it from the flexor carpi radialis and the deep fascia of the forearm; the small, or deep, head *arises* as a narrow bundle of fibers from the median aspect of the coronoid process of the ulna. The two heads unite at an acute angle, the median nerve passing between them to the deeper part of the forearm. The deeply placed ulnar head is easily recognized by the fact that it intervenes between the median nerve and the ulnar artery. The muscle then extends obliquely downward and lateralward, and is *attached* to the middle of the lateral surface of the shaft of the radius by a flat tendon which is overlapped by the supinator longus (*brachio-radialis*). The muscle is subcutaneous, except near and at its insertion, where it is covered by the supinator longus (*brachio-radialis*) and is crossed by the radial vessels and nerve. The radial border of the muscle forms the medial boundary of the triangle at the bend of the elbow, while the ulnar border is in relation with the flexor carpi radialis. Its under surface is in contact with the brachialis and flexor digitorum sublimis muscles, the median nerve, and the ulnar vessels. The median head of the muscle separates the median nerve anteriory from the ulnar vessels posteriorly.

Blood Supply.—From the radial, ulnar, and anastomotica magna (*inferior ulnar collateral*) arteries.

Nerve Supply.—From the median nerve.

Action.—Pronates and flexes the forearm.

The **flexor carpi radialis** *arises* by the common tendon from the medial condyle (*epicondyle*), also from the deep fascia and contiguous surfaces of the adjacent intermuscular septa. It passes down the forearm to the radial side of the front of the wrist, where it traverses a canal in the anterior annular (*transverse*

carpal) ligament and a groove upon the trapezium (*multangulum majus*), and is ultimately *attached* to the anterior surface of the base of the metacarpal bone of the index finger. A small slip passes to the base of the metacarpal bone of the middle finger. The groove in the trapezium (*multangulum majus*) is converted into a canal by a fibrous sheath, the canal being lined by a synovial membrane. This muscle is tendinous in its distal three-fifths; its belly is full and fusiform. It is superficial, with the exception of the small portion of the tendon which enters the anterior annular (*transverse carpal*) ligament; it lies upon the flexor digitorum sublimis, the flexor pollicis longus and the wrist-joint. Laterally, it is in contact with the pronator radii teres, and in its distal half is very near the radial vessels; medially and proximally, it lies against the palmaris longus muscle. Proximal to the wrist the median nerve is on the medial side of its tendon.

Blood Supply.—From the radial and the ulnar recurrent arteries.

Nerve Supply.—From the median nerve.

Action.—It flexes the wrist, is an accessory flexor of the elbow, and with the hand supinated it aids in pronation.

The **palmaris longus,** often absent (ten per cent of cases), is a slender fusiform muscle which *arises* by the common tendon from the medial condyle (*epicondyle*), also from the deep fascia and from the adjacent intermuscular septa. Its slender tendon passes over the anterior annular (*transverse carpal*) ligament to *terminate* in an expanded prolongation, which is continuous with the central portion of the palmar fascia, with the deep fascia over the thenar eminence, and with the anterior annular (*transverse carpal*) ligament at the base of that eminence. It is subcutaneous except at its origin where it is partly overlapped by the flexor carpi radialis. It lies upon the flexor digitorum sublimis, the median nerve, and the anterior (*volar radio-carpal*) ligament and is in relation with the flexor carpi ulnaris medially, and with the flexor carpi radialis laterally.

Blood Supply.—From the ulnar artery.

Nerve Supply.—From the median nerve.

Action.—It assists in making tense the palmar fascia, flexes the wrist, and aids slightly in elbow flexion.

The **flexor carpi ulnaris,** a long, flat **muscle,** embraces the radial side of the proximal part of the shaft of the ulna. It *arises* by two heads, one from the common tendon from the medial condyle (*epicondyle*), the other from the ulnar aspect of the olecranon process, and partly by an aponeurosis continued down from the proximal three-fifths of the dorsal margin of the ulna. Fibers also *arise* from the overlying deep fascia and the intermuscular septum between this muscle and the flexor digitorum sublimis. The interval between the condyloid and olecranon heads is spanned by a tendinous arch, under which pass the ulnar

nerve and the posterior ulnar recurrent artery. The muscle terminates in a tendon which runs along its anterior margin, and to which the lower fibers pass obliquely downward and forward. It is *inserted* into the pisiform bone, with a more or less fibrous connection with the anterior annular (*transverse carpal*) ligament, the unciform bone (*os hamatum*) and the base of the metacarpal bone of the little finger. It is the only muscle of the forearm attached to carpal bones. Its volar and ulnar surfaces are subcutaneous, and over much of their extent are intimately attached to the deep fascia, especially near the dorsal border of the ulna. It lies upon the flexor digitorum sublimis and flexor digitorum profundus muscles and the ulnar vessels and nerve. Its tendon is the guide for ligation of the ulnar artery, which it overlaps in the distal half of the forearm. Laterally, it is in contact with the belly of the palmaris longus muscle and the ulnar vessels and nerve.

Blood Supply.—From the ulnar artery.

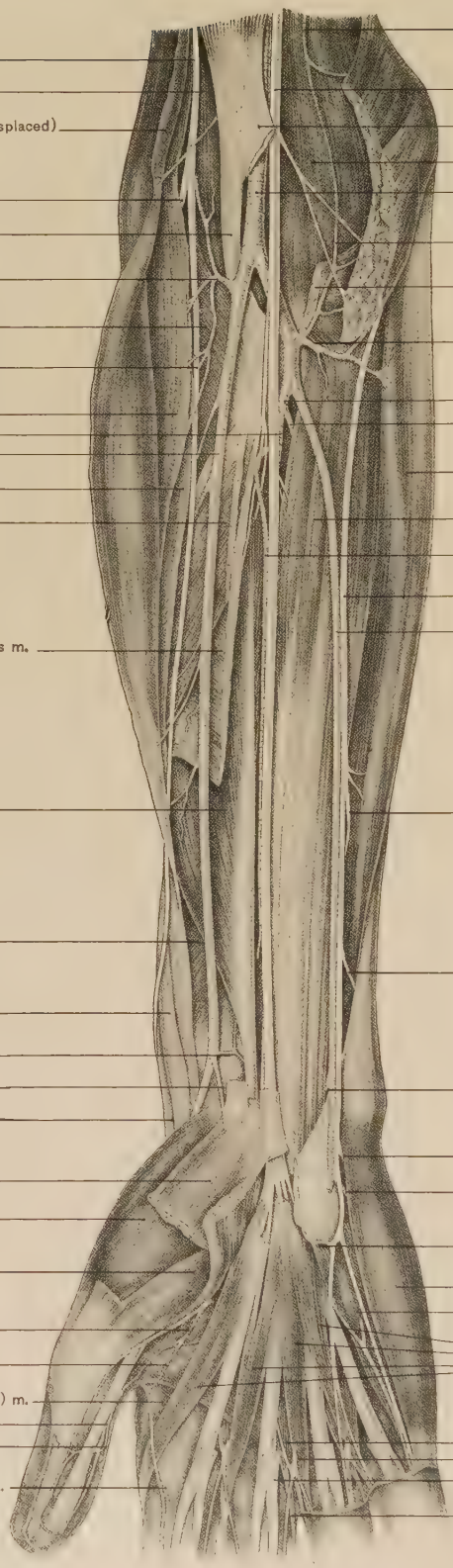
Nerve Supply.—From the ulnar nerve.

Action.—It flexes and adducts the wrist, and slightly flexes the forearm on the arm.

Owing to its extensive connection with the ulna this muscle, in amputation of the forearm cannot retract so much as the other muscles of this group.

The **flexor digitorum sublimis** (Plate CLVI) lies under the preceding four muscles and *arises* by three heads: from the humerus, the ulna, and the radius. The chief, or *humeral, head arises* from the medial condyle (*epicondyle*) from the common tendon of the flexor muscles, from the internal lateral (*ulnar collateral*) ligament of the elbow-joint, and from the adjacent intermuscular septa; the *ulnar head arises* from the ulnar side of the coronoid process of the ulna, just above and medial to the origin of the lesser head of the pronator radii teres; *the radial head arises* from the oblique line of the radius and the volar surface of that bone to a point below the insertion of the pronator radii teres. The fibers pass directly downward from the three origins as a broad, thick, fleshy mass, dividing in the distal third of the forearm into four tendons, which pass beneath the anterior annular (*transverse carpal*) ligament, along with the tendons of the flexor profundus, where they are arranged in two pairs, one behind the other. In this region they are surrounded by a synovial sheath. The anterior pair go to the middle and ring fingers, and the posterior pair to the index and little fingers. The tendons are *inserted* into the middle of the sides of the second phalanges of the four fingers. Each tendon splits to permit the passage of the tendon of the flexor digitorum profundus muscle between its segments, which will be seen in the dissection of the hand.

PLATE CLVII.



Musculo-spiral (radial) n.
Brachialis anticus (brachialis) m.
Supinator longus (brachio-radialis) m. (displaced)
Posterior (dorsal) interosseous n.
Biceps brachii tendon
Radial recurrent a.
Supinator brevis (supinator) m.
Radial (superficial branch of radial) n.
Extensor carpi radialis longus m.
Anterior (volar) interosseous a.
Radial a.
Extensor carpi radialis brevis m.
Pronator radii teres (pronator teres) m.
Radial origin of flexor digitorum sublimis m.
Flexor pollicis longus m.
Pronator quadratus m.
Extensor ossis metacarpi pollicis (abductor pollicis longus) tendon
Anterior (volar) carpal a.
Superficial volar a.
Extensor primi internodii pollicis (extensor pollicis brevis) tendon
Abductor pollicis (brevis) m.
Opponens pollicis m.
Lateral head of flexor pollicis brevis m.
Medial head of flexor pollicis brevis m.
Adductor pollicis m.
Abductor indicis (first dorsal interosseous) m.
Flexor pollicis longus tendon
Princeps pollicis a.
Radialis indicis (volaris indicis radialis) a.

Branch of anastomotica magna (inferior ulnar recurrent) a.
Median n.
Bicipital fascia (lacertus fibrosus)
Brachialis anticus (brachialis) m.
Brachial a.
Anterior (volar) ulnar recurrent a.
Coronoid head of pronator radii teres (pronator teres) m.
Posterior (dorsal) ulnar recurrent a.
Common interosseous a.
Posterior (dorsal) interosseous a.
Flexor carpi ulnaris m. (displaced)
Flexor digitorum profundus m.
Median a.
Ulnar n.
Ulnar a.
Dorsal cutaneous branch of ulnar n.
Posterior (dorsal) carpal a.
Anterior (volar) carpal a.
Deep branch ulnar n.
Deep branch ulnar a.
Loop between median n. and ulnar n.
Abductor minimi digiti (abductor digiti quinti) m.
Flexor brevis minimi digiti (flexor digiti quinti brevis) m.
Lumbricales muscles
Interosseous a.
Digital a.
Flexor digitorum sublimis tendon
Collateral digital (proper volar digital) a.

DEEP FLEXOR MUSCLES, RADIAL ARTERY, RADIAL (SUPERFICIAL BRANCH OF RADIAL) NERVE, ULNAR ARTERY, ULNAR NERVE, AND MEDIAN NERVE.

This muscle is covered by the pronator radii teres, the flexor carpi radialis, the palmaris longus, and the flexor carpi ulnaris, also by the radial vessels and nerve and the deep fascia. It rests upon the flexor digitorum profundus and the flexor pollicis longus, the ulnar vessels and nerve, and the median nerve. Its ulnar edge is against the flexor carpi ulnaris. Laterally, it is overlapped by the distal end of the pronator radii teres.

Blood Supply.—From the radial and ulnar arteries.

Nerve Supply.—From the median nerve.

Action.—It flexes the proximal interphalangeal, the metacarpo-phalangeal, and the wrist joints, and assists slightly in flexion of the elbow.

Dissection.—Displace the supinator longus (*brachio-radialis*) lateralward in order to expose the radial artery and nerve in the proximal part of the forearm. Separate the flexor carpi ulnaris from the flexor digitorum sublimis, and study the relations of the ulnar vessels and nerve. Then sever the pronator radii teres, flexor carpi radialis, palmaris longus, and flexor digitorum sublimis muscles, about three to five centimeters (one and a half to two inches) below the medial condyle (*epicondyle*), without cutting the median nerve, the ulnar artery, or the ulnar nerve. Reflect the severed muscles in order to obtain a view of the structures beneath: the flexor digitorum profundus, flexor pollicis longus, pronator quadratus muscles, the median nerve, the ulnar vessels, and the anterior interosseous (*volar interosseous*) vessels and nerve. (Plate CLVII.)

The **flexor digitorum profundus** *arises* from the proximal two-thirds of the volar and medial side of the shaft of the ulna, and at its proximal end interdigitates with the insertion of the brachialis in the same manner as that muscle at its origin does with the deltoid insertion. It also *arises* from the ulnar side of the coronoid process of the ulna and by the aponeurosis from the proximal two-thirds of the dorsal border of the ulna, in common with the ulnar origin of the flexor carpi ulnaris, and from the ulnar half of the interosseous membrane. The muscle forms a broad thick tendon which passes beneath the anterior annular (*transverse carpal*) ligament, covered by the tendons of the flexor digitorum sublimis and enveloped in the same synovial sac, and divides in the forearm into four tendons, which pass to the bases of the terminal phalanges, piercing the tendons of the flexor digitorum sublimis. A *lumbricalis muscle* is attached to each one of these tendons in the palm. The flexor digitorum profundus muscle lies beneath the flexor digitorum sublimis and flexor carpi radialis muscles, the ulnar vessels and nerve, and the median nerve. It rests upon the ulna, the interosseous membrane, and the pronator quadratus muscle. Medially, it is in contact with the flexor carpi ulnaris, and laterally, with the anterior interosseous (*volar interosseous*) artery and nerve, and the flexor pollicis longus muscle.

Blood Supply.—From the ulnar and the anterior interosseous (*volar interosseous*) arteries.

Nerve Supply.—From the ulnar nerve, and the anterior interosseous (*volar interosseous*) branch of the median nerve.

Action.—It flexes the terminal phalanges and also the interphalangeal, metacarpo-phalangeal and wrist joints.

The **flexor pollicis longus** *arises* from the front of the shaft of the radius, between the tuberosity and the oblique ridge proximally, and the insertion of the pronator quadratus distally, and from the adjacent interosseous membrane; sometimes also by a small slip from the medial condyle (*epicondyle*) of the humerus or from the ulnar side of the coronoid process of the ulna, adjoining the insertion of the brachialis. It passes down the radial side of the forearm to about its middle, where it terminates in a flattened tendon, which passes under the anterior annular (*transverse carpal*) ligament and between the two heads of the flexor pollicis brevis, *to be attached* to the base of the last phalanx of the thumb. It lies beneath the flexor digitorum sublimis, the supinator longus (*brachio-radialis*), the tendon of the flexor carpi radialis, and the radial vessels and nerve, and rests upon the radius, the interosseous membrane, and the pronator quadratus. Upon its ulnar side lie the flexor digitorum profundus, the anterior interosseous (*volar interosseous*) artery and nerve; upon its radial side are the supinator brevis, the insertion of the pronator radii teres, the radial origin of the flexor digitorum sublimis, and the tendons of the supinator longus (*brachio-radialis*), and the extensores carpi radialis longus and brevis.

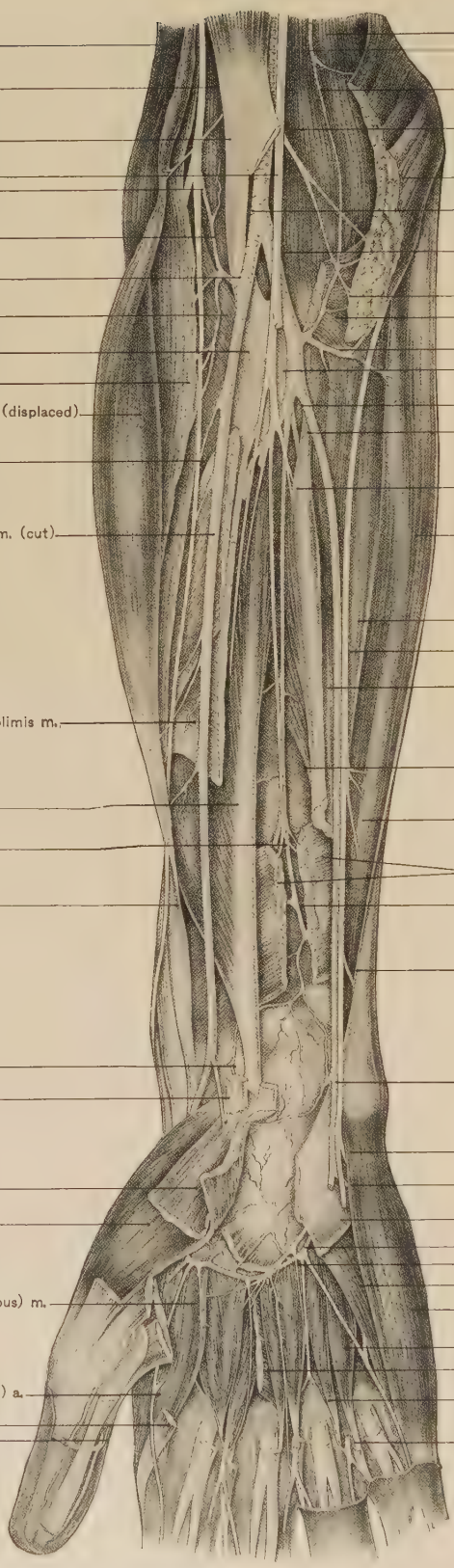
Blood Supply.—From the radial and anterior interosseous (*volar interosseous*) arteries.

Nerve Supply.—From the anterior interosseous (*volar interosseous*) nerve.

Action.—It flexes the terminal phalanx of the thumb, aids in flexion of the proximal phalanx, and is also a flexor of the wrist.

The **pronator quadratus** is a flat, square **muscle,** which lies in front of the distal ends of the radius and ulna and the interosseous membrane. It *arises* from the oblique ridge on the volar surface of the distal fourth of the ulna, and from the aponeurosis covering the median third of the muscle; thence its fibers cross the forearm transversely and somewhat obliquely for *insertion* into the lateral border, and the volar and medial surfaces of the distal fourth of the radius. It rests upon the radius, the ulna, the interosseous membrane, and the anterior interosseous (*volar interosseous*) vessels and neve, and is covered by the tendons of the flexor digitorum profundus, flexor pollicis longus, and flexor carpi radialis muscles, the radial and ulnar vessels and ulnar nerve. The muscle varies, some-

PLATE CLVIII.



Supinator longus (brachio-radialis) m.
Musculo-spiral (radial) n.
Brachialis anticus (brachialis) m.
Brachial a.
Posterior (dorsal) interosseous n.
Radial (superficial branch of radial) n.
Radial recurrent a.
Supinator brevis (supinator) m.
Radial a.
Extensor carpi radialis longus m.
Supinator longus (brachio-radialis) m. (displaced)
Extensor carpi radialis brevis m.
Pronator radii teres (pronator teres) m. (cut)
Radial origin of flexor digitorum sublimis m.
Flexor pollicis longus m.
Anterior (volar) interosseous a. piercing interosseous membrane
Radial (superficial branch of radial) n.
Anterior (volar) radial carpal a.
Superficial volar a.
Abductor pollicis m.(cut)
Opponens pollicis m.
Abductor indicis (first dorsal interosseous) m.
Radialis indicis (volaris indicis radialis) a.
Lumbrical m.(cut)
Princeps pollicis a.

Branch of anastomotica magna (inferior ulnar collateral) a.
Median n.
Brachialis anticus (brachialis) m.
Bicipital fascia (lacertus fibrosus)
Condyloid origin of flexors
Biceps brachii tendon.
Ulnar a.
Coronoid head of pronator radii teres (pronator teres) m.
Anterior ulnar recurrent a.
Posterior (dorsal) ulnar recurrent a.
Anterior (volar) interosseous n.
Common interosseous a.
Posterior (dorsal) interosseous a.
Anterior (volar) interosseous a.
Flexor carpi ulnaris m.(displaced)
Ulnar n.
Ulnar a.
Flexor digitorum profundus m. (displaced)
Interosseous membrane.
Dorsal cutaneous branch of ulnar n.
Pronator quadratus m.(cut)
Anterior (volar) branch of anterior (volar) interosseous a.
Posterior (dorsal) ulnar carpal a.
Anterior (volar) ulnar carpal a.
Deep branch of ulnar n.
Deep branch of ulnar a.
Flexor brevis minimi digiti (flexor digiti quinti brevis) m. (cut)
Deep branch of ulnar n.
Deep palmar (deep volar) arch.
Opponens digiti quinti m.
Abductor digiti quinti m.
Interosseous m.
Adductor pollicis m.(cut)
Interosseous a.
Digital a.

ARTERIES AND NERVES OF FRONT OF FOREARM.

times arising from the radius or the ulna, or both, and may be inserted into the carpus; it is occasionally altogether absent.

Blood Supply.—From the anterior interosseous (*volar interosseous*) branch of the median artery.

Nerve Supply.—From the anterior interosseous (*volar interosseous*) nerve.

Action.—It pronates the forearm.

The **interosseous membrane** extends between the interosseous margins of the radius and ulna, firmly connecting the shafts of those bones and forming a dividing wall between the front and back of the forearm. It extends proximally to within two and a half centimeters (one inch) of the bicipital (*radial*) tuberosity and distally to the distal radio-ulnar articulation. Its fibers pass distally and medialward from the edge of the radius to the radial margin of the ulna. It affords attachment to the deep muscles of the front and the back of the forearm, supports the anterior interosseous (*volar interosseous*) artery and its venæ comites, and the anterior interosseous (*volar interosseous*) nerve. The anterior interosseous (*volar interosseous*) artery pierces the membrane about three centimeters (one and a quarter inches) above its distal end. It is relaxed in pronation of the forearm. The gap between the proximal margin of the membrane and the oblique cord is known as the *hiatus interosseous*, through which the posterior interosseous vessels pass to reach the back of the forearm. The interosseous membrane strengthens the ulna and radius and enables the hand to support a weight or to push against an object in extension. The membrane is widest distally and narrowest proximally. The preservation of the space which it bridges is most important in fractures of the forearm if the rotating power of the wrist is to be preserved.

The **oblique ligament** (**chorda obliqua**) is a round, fibrous cord, connected above to the tuberosity of the ulna located at the base of its coronoid process, whence it extends distally and lateralward to the radius to a point a little below the bicipital (*radial*) tuberosity. It is connected by a thin membrane to the proximal border of the interosseous membrane, with the fibers of which it forms a right angle, and is regarded as a specialization of the fascia covering the supinator brevis (*supinator*). It sometimes is absent.

The **radial artery** (Plate CLVIII) begins at the bifurcation of the brachial artery, about one centimeter (one-half inch) distal to the elbow-joint. Its course is more nearly in a direct line with the parent trunk than is that of the ulnar artery, and is represented by a line drawn from a point one centimeter (one-half inch) below the middle of the bend of the elbow to the medial side of the base of the styloid process of the radius, the line curving slightly lateralward. It passes down the radial side of the forearm along the ulnar margin of the supinator longus (*brachio-radialis*), which is the muscle of reference for its ligation, and by which

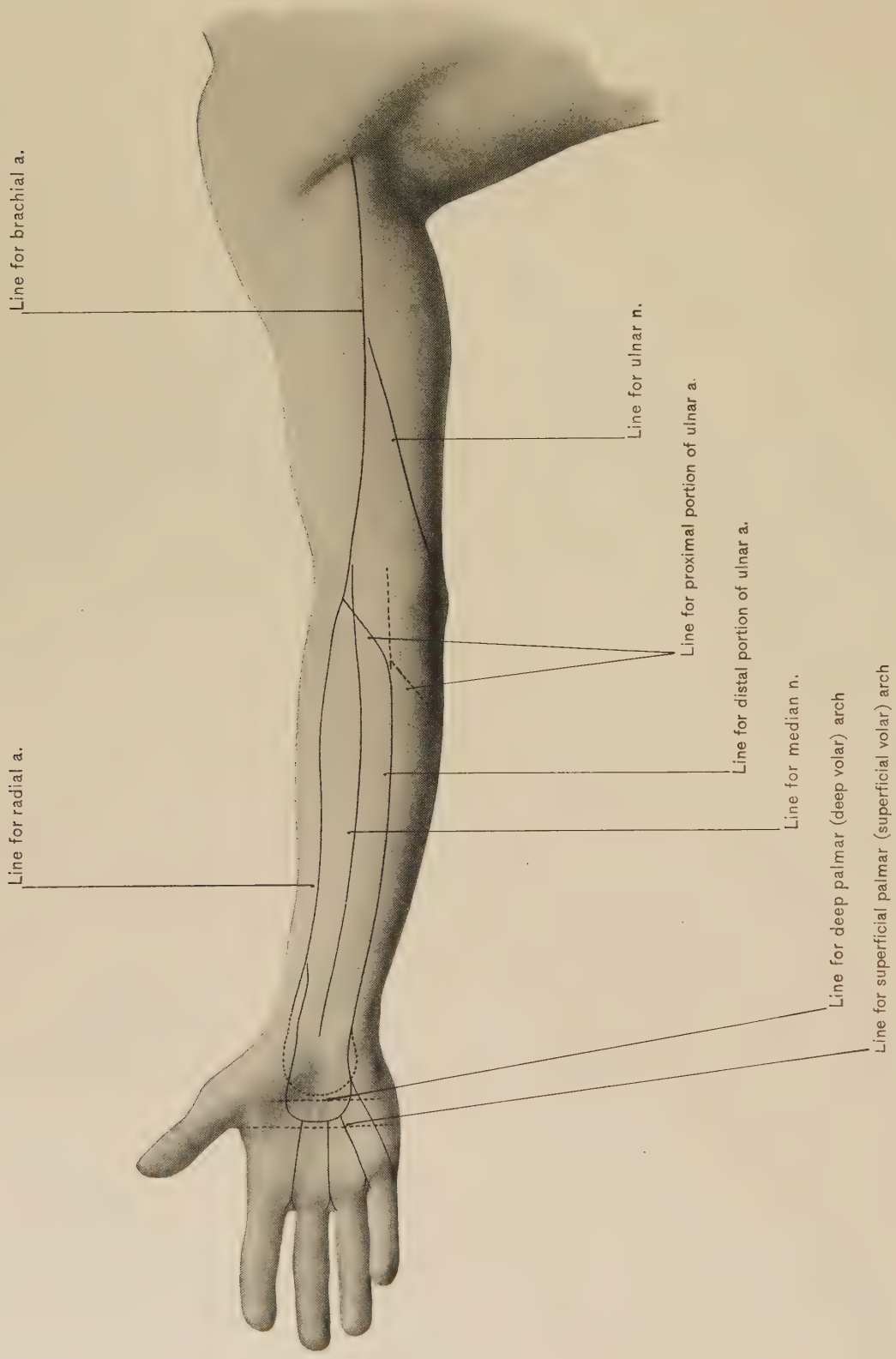
it is overlapped in about the proximal third of its course. At the wrist or base of the thumb it turns backward over the external lateral (*radial collateral*) ligament of the wrist-joint beneath the extensors of the thumb, and then passes between the two heads of the abductor indicis (*first dorsal interosseous*) muscle into the palm of the hand, where it assists in forming the deep palmar arch. It is superficial in the forearm, except at its proximal part where it is covered by the supinator longus (*brachio-radialis*). From above downward it rests upon the tendon of the biceps, the supinator brevis (*supinator*), the pronator radii teres, the radial head of the flexor digitorum sublimis, the flexor pollicis longus, the pronator quadratus, the radius, and the external lateral (*radial collateral*) ligament. In its proximal third it lies between the supinator longus (*brachio-radialis*) and the pronator radii teres; while in its distal two-thirds it passes between the tendons of the supinator longus (*brachio-radialis*) and the flexor carpi radialis. It is accompanied by its venæ comites, and at its middle third has the radial nerve upon its radial side. Filaments of the musculo-cutaneous nerve are closely related to its distal part as it courses around the wrist. Its branches in the forearm are: the radial recurrent, the muscular, the superficial volar, and the anterior (*volar*) carpal; at the wrist the posterior (*dorsal*) carpal, the metacarpal, the dorsalis pollicis (*first dorsal metacarpal*), and the dorsalis indicis (*first dorsal metacarpal*), and in the hand the princeps pollicis, radialis indicis, the perforating, the palmar interosseous (*volar metacarpal*), and the recurrent carpal. At this time, the branches given off in the forearm will be considered.

The **radial recurrent** arises from the lateral side of the radial artery, passes downward between the supinator brevis (*supinator*) and supinator longus (*brachio-radialis*) muscles and betweenthe radial and dorsal interosseous nerves; thence proximally, in company with the musculo-spiral (*radial*) nerve, between the brachialis and supinator longus (*brachio-radialis*) muscles, both of which it partially supplies. It anastomoses with the terminal branches of the superior profunda (*profunda brachii*) in front of the lateral condyle (*epicondyle*) and between the last-named two muscles. From its arch it sends muscular branches to the supinator and extensor muscles, some of which pass beneath the latter to anastomose with the interosseous recurrent branch of the posterior (*dorsal*) interosseous. It also supplies the elbow-joint.

The *muscular branches* arise from the radial in its downward course, and supply the muscles upon the radial side of the forearm.

The **superficial volar** is a slender vessel which arises from the radial artery near the wrist, just before it crosses the external lateral (*radial collateral*) ligament, and passes over the thenar eminence, sometimes running beneath the abductor pollicis (*abductor pollicis brevis*) muscle. It supplies the muscles of

PLATE CLIX.


Line for brachial a.
Line for ulnar n.
Line for proximal portion of ulnar a.
Line for distal portion of ulnar a.
Line for radial a.
Line for median n.
Line for deep palmar (deep volar) arch
Line for superficial palmar (superficial volar) arch

LINES OF ARTERIES OF UPPER EXTREMITY AND OF MEDIAN AND ULNAR NERVES.

the thenar eminence, and often anastomoses with the ulnar artery to assist in the formation of the superficial palmar arch. Sometimes the superficial volar arises higher than usual and runs beside the radial, and thus gives the palpating finger the sensation of a double pulse, and at times it is so large that it can be seen pulsating from the wrist downward.

The **anterior (volar) carpal** arises from the radial artery near the distal margin of the pronator quadratus, whence it passes medialward to anastomose with the anterior (*volar*) carpal branch of the ulnar artery, thus forming a pre-carpal loop, the **anterior (volar) carpal arch,** from which branches descend to nourish the wrist-joint, anastomosing with branches of the deep palmar (*deep volar*) arch. The posterior (*dorsal*) carpal, metacarpal, dorsalis pollicis, and dorsalis indicis will be described with the back of the wrist and hand.

The **ulnar artery,** larger than the radial, is the other terminal branch of the brachial artery. It at once turns toward the ulnar side of the forearm, describing a curve toward the ulnar side which it reaches at the junction of the proximal and middle thirds of the forearm, after which it skirts the ulnar border of the forearm to the wrist. A line drawn with its convexity toward the ulnar side from a point one centimeter (one-half inch) below the middle of the bend of the elbow to the junction of the proximal with the middle third of the ulnar border of the forearm will represent the course of the proximal, or deep, portion of this vessel, and a line drawn from a point midway between the medial condyle (*epicondyle*) and the middle of the bend of the elbow to the radial side of the pisiform bone represents its course in the distal two-thirds of the forearm (Plate CLIX). It crosses the anterior annular (*transverse carpal*) ligament on the radial side of the pisiform bone, and runs across the palm, forming the superficial palmar (*superficial volar*) arch, which is usually completed by anastomosis with the superficial volar artery. In its proximal half the ulnar artery is deep, being covered by all of the superficial flexors except the flexor carpi ulnaris; in its distal half it is more superficial, being overlapped by the tendon of the flexor carpi ulnaris, while immediately proximal to the wrist it is subcutaneous, and lies between the tendon of the flexor carpi ulnaris and the deepest tendon of the flexor digitorum sublimis. It lies, from above downward, upon the brachialis, the flexor digitorum profundus, and the anterior annular (*transverse carpal*) ligament. It has two venæ comites. As its proximal part the median nerve crosses in front of it, being separated from it by the deep head of the pronator radii teres muscle, while the ulnar nerve is upon the radial side of its distal two-thirds. In the proximal third of the course of the artery the ulnar nerve lies some distance to its ulnar side. When the ulnar artery has a high origin from the brachial, it usually lies upon the superficial flexor muscles, instead of beneath them, and is

thus more liable to injury. Its branches in the forearm are: the anterior (*volar*) ulnar recurrent, the posterior (*dorsal*) ulnar recurrent, the common interosseous, and the muscular; at the wrist, the anterior (*volar*) and posterior (*dorsal*) carpal; in the hand, the deep, or communicating, branch; it continues as the superficial palmar (*superficial volar*) arch. As in the case of the radial artery, only the branches given off in the forearm will at this time be considered.

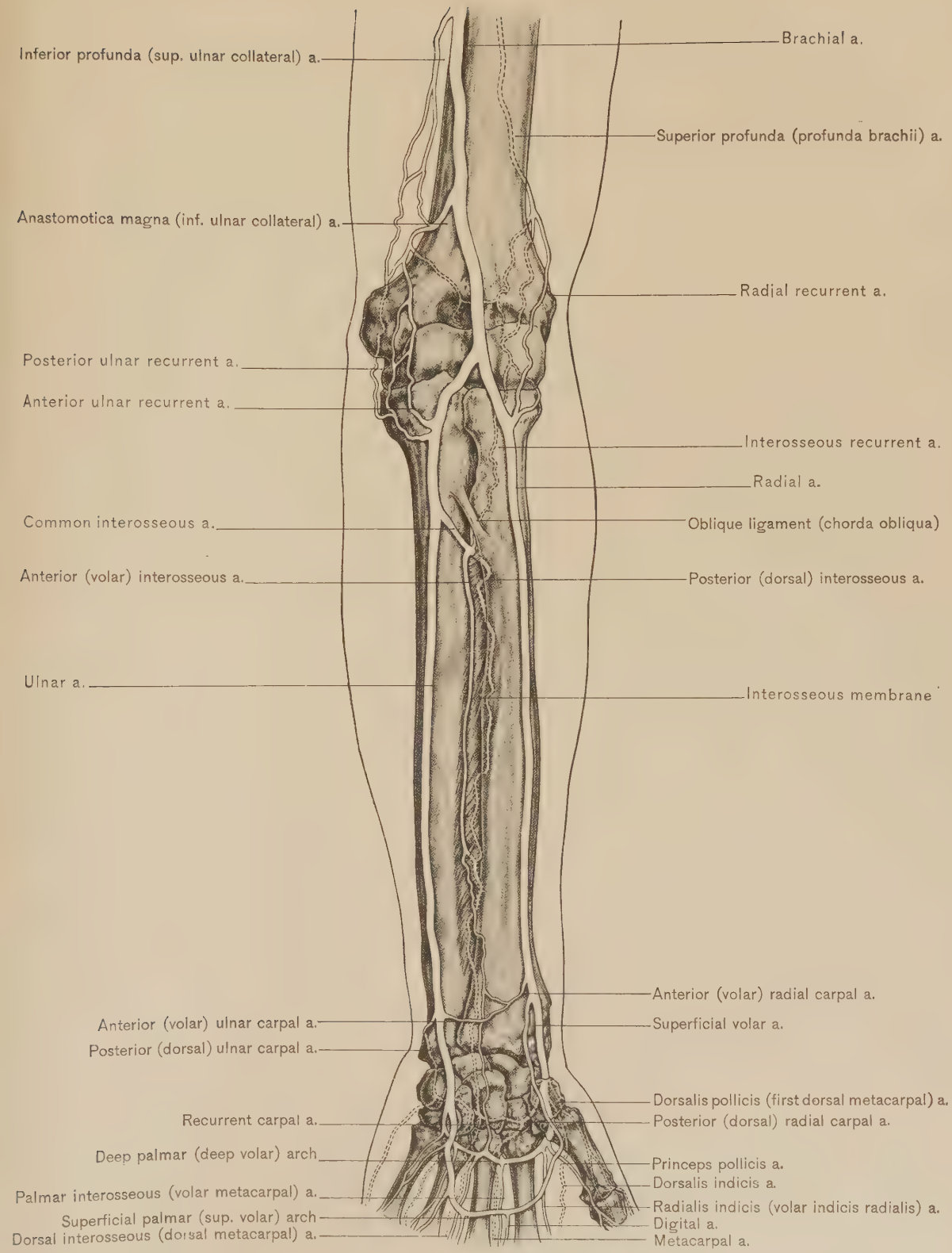
The **anterior (volar) ulnar recurrent artery** arises from the ulnar immediately below its origin, and passes medialward and proximally upon the brachialis and behind the pronator radii teres, to the front of the medial condyle (*epicondyle*) of the humerus, where it anastomoses with the anastomotica magna (*inferior ulnar collateral*) and the inferior profunda (*superior ulnar collateral*) arteries. (Plate CLX.)

The **posterior (dorsal) ulnar recurrent artery,** larger than the anterior (*volar*) ulnar recurrent, arises below that vessel and passes medialward and posteriorly under the flexor digitorum sublimis. It then courses between the two heads of the flexor carpi ulnaris, in relation with the ulnar nerve, to the back of the medial condyle (*epicondyle*). It supplies the elbow-joint, the ulnar nerve, and the adjacent muscles, and anastomoses with the inferior profunda (*superior ulnar collateral*), anastomotica magna (*inferior ulnar collateral*), and interosseous recurrent arteries.

The **common interosseous artery** is the thickest and shortest branch of the ulnar. It is given off opposite the tuberosity of the radius about two or three centimeters (three-quarters to one and a quarter inches) below the origin of the ulnar artery, whence it passes distally and lateralward to the proximal margin of the interosseous membrane and divides into the anterior (*volar*) and posterior (*dorsal*) interosseous arteries.

The **anterior (volar) interosseous artery,** accompanied by venæ comites and the anterior (*volar*) interosseous nerve, descends along the middle of the front of the interosseous membrane, between the flexor pollicis longus and the flexor digitorum profundus, and supplies nutrient branches to both muscles and to the radius and ulna. It eventually perforates the interosseous membrane, beneath the proximal border of the pronator quadratus, to reach the back of the forearm. Under the proximal border of the pronator quadratus it gives off a branch which supplies this muscle and anastomoses with the anterior (*volar*) carpal branches of the radial and ulnar and the recurrent carpal branches of the deep palmar (*deep volar*) arch. In the proximal part of the forearm it also gives off a long slender branch which accompanies the median nerve and is called the *comes nervi mediani*, or *median artery*. This is sometimes quite large, and then assists in the formation of the superficial palmar (*superficial volar*) arch. The posterior interosseous is described with the back of the forearm.

PLATE CLX.



ARTERIES OF FOREARM AND HAND.

The *muscular branches*, variable in number, supply the adjacent muscles.

The **anterior (volar) carpal artery** is a small branch given off immediately above the anterior annular (*transverse carpal*) ligament. It passes laterally beneath the tendons of the flexor digitorum profundus, and anastomoses with the anterior (*volar*) carpal branch of the radial, as well as with derivatives of the anterior (*volar*) interosseous, and the recurrent carpal branches of the deep palmar (*deep volar*) arch, and with the corresponding branch of the radial it forms the precarpal arch. The posterior (*dorsal*) carpal branch will be described with the back of the wrist and hand.

The **median nerve** enters the forearm upon the medial side of the brachial artery, which lies next and medial to the biceps tendon, passes between the two heads of the pronator radii teres, the deep head of which separates it from the ulnar artery, and continues straight down the forearm to the wrist upon the flexor digitorum profundus, covered by the flexor digitorum sublimis. About five centimeters (two inches) proximal to the anterior annular (*transverse carpal*) ligament it becomes superficial and lies between the lateral tendon of the flexor digitorum sublimis and the tendon of the flexor carpi radialis; it then passes under the anterior annular (*transverse carpal*) ligament, resting upon the flexor tendons. It is accompanied and supplied by the median artery. In the forearm it gives off articular, muscular, anterior (*volar*) interosseous, and palmar cutaneous branches. For exposure of the median nerve above the wrist see Plate CCVIII.

The *articular branches*, two in number, supply the elbow-joint.

The *muscular branches* supply all the muscles of the superficial group except the flexor carpi ulnaris, that is, the pronator radii teres, the flexor carpi radialis, the palmaris longus, and the flexor digitorum sublimis.

The **anterior (volar) interosseous** nerve, the longest branch of the median, arises beneath the proximal part of the flexor digitorum sublimis, and accompanies the anterior (*volar*) interosseous artery between the flexor pollicis longus and flexor digitorum profundus. It supplies the flexor pollicis longus, the radial side of the flexor digitorum profundus, and the pronator quadratus.

The **palmar cutaneous branch** arises in the distal third of the forearm, pierces the deep fascia near the anterior annular (*transverse carpal*) ligament, and divides into lateral and medial branches, which pass in front of the ligament. The lateral branch supplies the skin of the thenar eminence and communicates with the musculo-cutaneous and the radial (*superficial branch of the radial*) nerves; the medial branch supplies the skin of the palm, except on the ulnar side, and communicates with the ulnar palmar cutaneous branch.

The **radial nerve** (**superficial branch of the radial nerve**), one of the terminal branches of the musculo-spiral (*radial*), passes along the front of the radial side of the forearm, accompanying the radial artery along its middle third. In the proximal part of its course it is overlapped by the belly of the supinator longus (*brachio-radialis*), and at about seven and a half centimeters (three inches) proximal to the wrist curves backward under the tendon of that muscle and pierces the deep fascia at the radial border of the forearm, to divide into lateral and medial branches, which supply the skin of the dorsum of the hand and fingers.

The **ulnar nerve,** emerging from between the olecranon and the medial condyle (*epicondyle*) of the humerus in the proximal part of the forearm, passes down the volar and ulnar side of the forearm upon the flexor digitorum profundus between the two heads of the flexor carpi ulnaris muscle, which muscle also covers it, while in the distal part of its course it lies to the radial side of the flexor carpi ulnaris muscle and its tendon. Upon its radial side, as far down as the pisiform bone, it is accompanied by the distal two-thirds of the ulnar artery. In the forearm the ulnar nerve gives off articular, muscular, cutaneous, and dorsal cutaneous branches, and frequently communicates with the median nerve.

The *articular branches* are given off behind the medial condyle (*epicondyle*), to supply the elbow-joint, and just proximal to the carpus, to supply the wrist-joint.

Of the *muscular branches*, the one to the flexor carpi ulnaris arises in the proximal part of the forearm; the other arises more distally, and passes to the medial part of the flexor digitorum profundus.

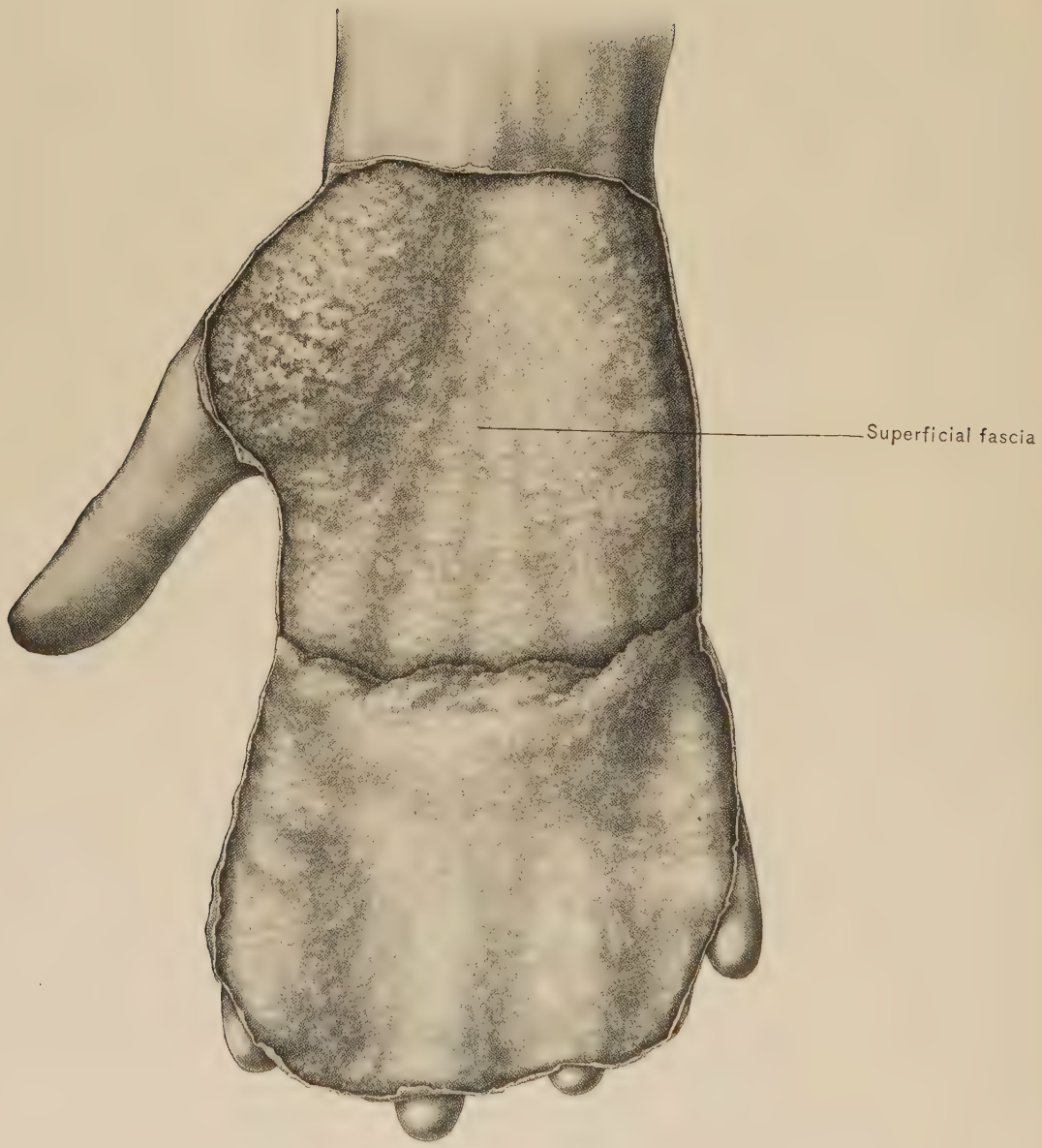
The *cutaneous branches* are two small nerves arising by a common trunk in the middle of the forearm. The shorter, and more superficial, descends to the skin of the ulnar side of the wrist, pierces the deep fascia, and joins a branch of the internal cutaneous (*medial cutaneous nerve of forearm*), while the other, a deeper branch, accompanies the ulnar artery, lying upon its volar surface, to supply the skin of the ulnar side of the palm of the hand. This branch communicates with twigs from the median, and is called the *palmar cutaneous branch*.

The *dorsal cutaneous branch* arises about seven and a half centimeters (three inches) above the wrist and passes backward, under the flexor carpi ulnaris to the posterior surface of the wrist, where it pierces the deep fascia and divides into one communicating and two digital branches, which supply the skin and fascia of the ulnar side of the hand, both sides of the little finger, and the adjacent side of the ring finger. The communicating branch inosculates with the posterior branch of the internal cutaneous (*medial cutaneous nerve of forearm*), and the digital branches with the adjacent ones from the radial (*superficial branch of the radial*) nerve.

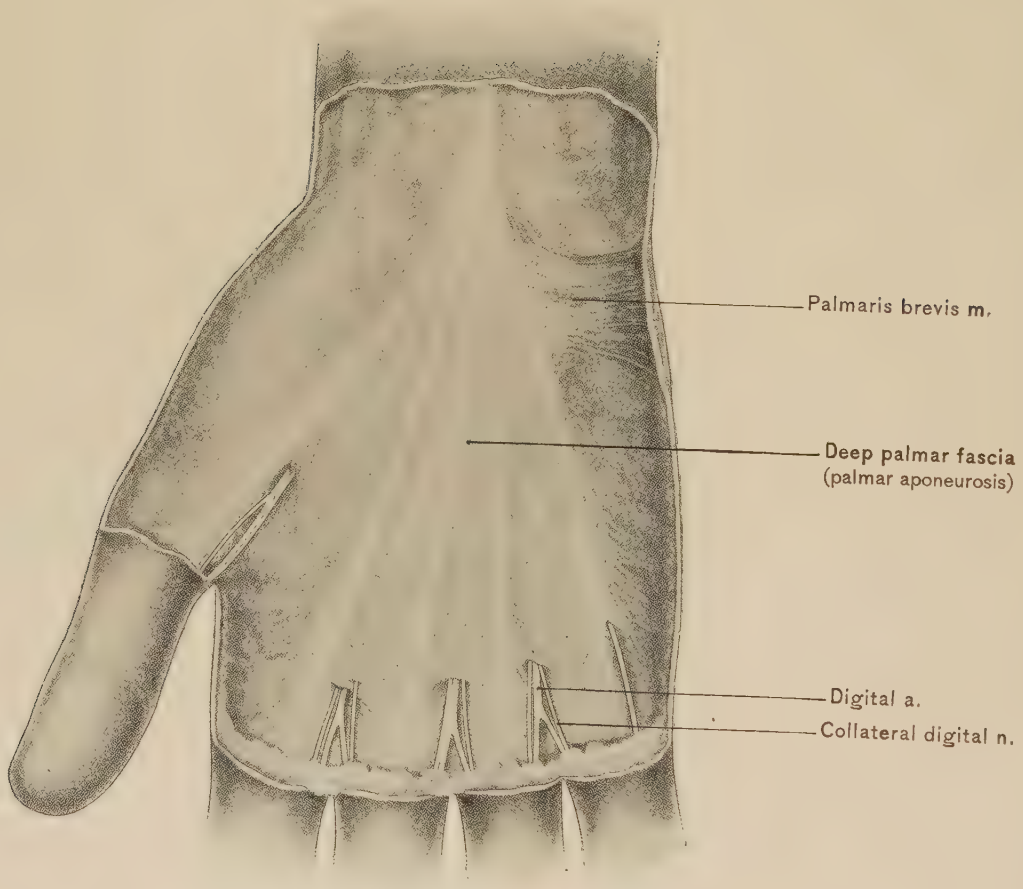
PLATE CLXI.

INCISIONS FOR DISSECTION.

PLATE CLXII.



SUPERFICIAL PALMAR FASCIA.



DEEP PALMAR FASCIA (PALMAR APONEUROSIS) AND PALMARIS BREVIS MUSCLE.

THE FRONT OF THE HAND

Dissection (Plate CLXI).—From the medial end of the incision which has been made across the front of the wrist, make another along the ulnar border of the palm as far as the junction of the latter with the fifth finger. From the lateral end of the transverse incision make a third along the radial border of the thenar eminence to the base of the first phalanx of the thumb, then around the palmar surface of the thumb, and along the radial border of the palm to its junction with the index finger. Reflect the flap of integument thus marked out distally, exposing the superficial fascia. In dissecting the thumb and fingers the skin is incised in the median line and reflected laterally. The skin of the palm is sensitive and well supplied with sweat glands, but has no sebaceous glands.

Superficial fascia (Plate CLXII).—The superficial fascia of the palm is dense but thin, and closely connects the skin with the deep fascia, resembling in this respect that of the scalp and the sole of the foot; over the thenar and hypothenar eminences it is more delicate. The fat in the palm of the hand presents a somewhat lobulated appearance, and when an incision is made through the skin, small masses of adipose tissue protrude through the opening. This fat serves as a protection for the vessels and nerves. It contains the palmaris brevis muscle, when present, the ulnar vessels and nerve, the palmar cutaneous branches of the ulnar and median nerves, and the superficial transverse ligament.

The **palmaris brevis muscle** (Plate CLXIII) is an insignificant, quadrilateral, subcutaneous muscle embedded in the granular superficial fascia on the ulnar side of the palm. It consists of a series of slightly divergent fasciculi which *arise* from the central palmar fascia and the anterior annular (*transverse carpal*) ligament, pass over the hypothenar eminence, and are *inserted* into the skin of the ulnar border of the palm.

Blood Supply.—From the ulnar artery.

Nerve Supply.—From the ulnar nerve. The ulnar vessels and nerve occupy the superficial fascia on the radial side of the pisiform bone, where their deep branches are given off.

Action.—Wrinkling the skin on the ulnar border of the hand, and deepening the hollow of the hand by raising up the skin and the superficial fascia.

Palmar cutaneous nerves.—Trace the palmar cutaneous branches of the median, radial, and ulnar nerves to their termination. That of the *median* passes between the tendons of the flexor carpi radialis and palmaris longus muscles and over the anterior annular (*transverse carpal*) ligament. It supplies the hollow of the palm and the adjacent border of the thenar eminence. That of the *ulnar nerve* passes into the hand in front of, and accompanies the ulnar artery, and supplies the ulnar

side of the hollow of the palm; while that of the *radial* supplies the radial margin of the thenar eminence.

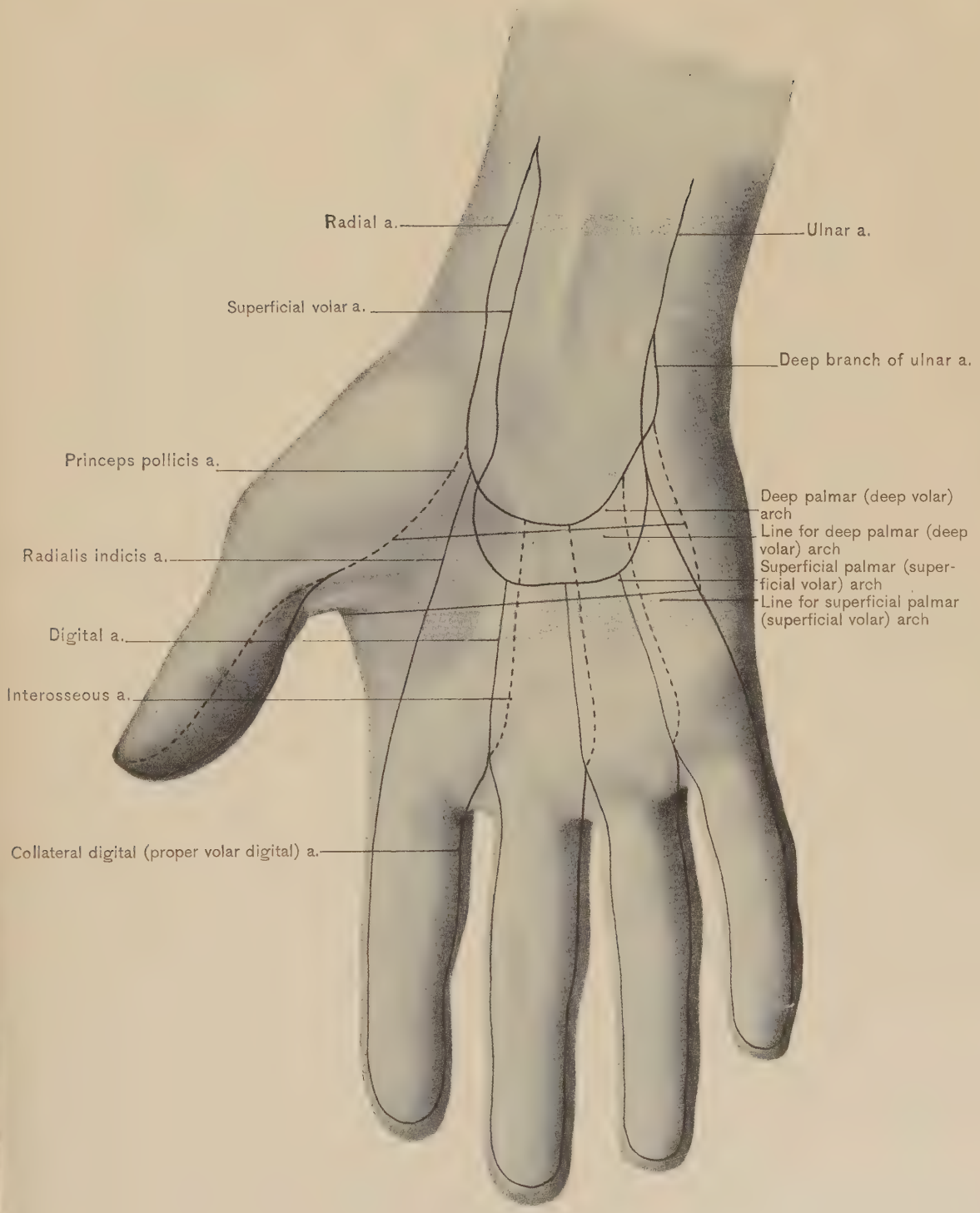
The **superficial transverse ligament,** or fasciculus, is a band of fibers which crosses the roots and webs of the fingers and connects the slips of the central portion of the palmar fascia.

Dissection.—In removing the superficial palmar fascia (*aponeurosis*) begin at the wrist and working toward the digital clefts dissect it free from the underlying deep palmar fascia.

This exposes the **anterior annular (transverse carpal) ligament** of the wrist, a thickened band of the deep fascia of the forearm, which extends from the pisiform and the hook of the unciform bone (*os hamatum*), upon the ulnar side of the wrist, to the tuberosity of the scaphoid (*navicular*) and the ridge of the trapezium (*multangulum majus*) upon the radial side of the wrist. It is firm, dense, and unyielding, gives origin to most of the muscles of the thenar and hypothenar eminences, and converts the hollow on the volar surface of the wrist into a tunnel for the passage of some of the structures of the forearm which are destined for the front of the hand. It is crossed by the following structures, enumerated in their order from the ulnar to the radial side: the tendon of the flexor carpi ulnaris, part of which it receives for insertion; the ulnar nerve, situated at the radial side of that tendon; the ulnar artery and its venæ comites; the palmar cutaneous branches of the ulnar and median nerves; the palmaris longus, part of which it receives for insertion, and the tendon of the flexor carpi radialis, which passes over its proximal margin and then pierces it. The tunnel beneath the ligament gives passage to the following structures: the tendons of the flexor digitorum sublimis and flexor digitorum profundus, the tendon of the flexor pollicis longus and the median nerve.

The **great carpal or palmar bursa** (Plate CLXIV).—In this tunnel there are two synovial sacs, separated by the median nerve; the lateral one invests the tendon of the flexor pollicis longus and extends upon the first phalanx of the thumb; the medial one invests the tendons of the flexor digitorum sublimis and flexor digitorum profundus and extends to the middle of the palm. Upon the proximal two phalanges of the fingers the flexor tendons are also invested by a synovial sheath which lines their fibrous sheaths. The synovial sheath on the little finger is usually described as being continuous with the medial sac of the great carpal bursa, while the synovial sheaths on the tendons of the index, middle, and ring fingers cease at the heads of the metacarpal bones and do not communicate with the great carpal bursa. The arrangement of these sheaths probably differs somewhat in individuals. Some authors claim that only exceptionally does the sheath for the little finger communicate with the main, or medial

PLATE CLXIV.


Radial a.
Ulnar a.
Superficial volar a.
Deep branch of ulnar a.
Princeps pollicis a.
Deep palmar (deep volar) arch
Line for deep palmar (deep volar) arch
Radialis indicis a.
Superficial palmar (superficial volar) arch
Line for superficial palmar (superficial volar) arch
Digital a.
Interosseous a.
Collateral digital (proper volar digital) a.

PALM OF HAND — LINES OF ARTERIES.

synovial sac. These sacs form what is called the *great carpal bursa*, which extends two to four centimeters (one half to one and a half inches) into the forearm, and when distended, is constricted in the middle into an hour-glass shape by the anterior annular (*transverse carpal*) ligament. Inflammation of the sheath of the flexor tendon over the proximal phalanx of the thumb by extension may involve the lateral sac of the great carpal bursa, while inflammation of the sheath of the flexor tendons of the little finger may implicate the medial sac. When, as occasionally happens, the two sacs communicate in front of the median nerve, inflammation of one is readily communicated to the other. Purulent collections in the great carpal bursa require early and free incision, and, in some cases, division of the anterior annular (*transverse carpal*) ligament. Purulent collections in the sheaths of the flexor tendons of the index, middle, and ring fingers, by reason of the anatomic conditions, do not extend into the palm further than the heads of the metacarpal bones.

The **deep palmar fascia** (**palmar aponeurosis**) (Plate CLXIII) which may be considered as a continuation of the palmaris longus tendon is intimately united to the skin in the middle of the palm, but less so at the sides. It consists of a thick, triangular, central portion and two thin lateral portions. The dense *central portion*, which may be divided into a lateral and a medial part, protects the underlying vessels, nerves, and tendons from injury. It is triangular in shape and narrow at its origin from the distal border of the anterior annular (*transverse carpal*) ligament, where it is strengthened by the broadened tendon of the palmaris longus. In its passage through the palm it expands to divide into four digital slips, one each going to the base of each finger; not uncommonly an additional slip passes to the thumb. Each slip subdivides to permit the passage of the digital flexor tendons, the divisions being then inserted into the sides of the bases of the first phalanges and the deep transverse (*transverse metacarpal*) ligament which connects the heads of the metacarpal bones of the fingers. Each slip is also continuous with the fibrous sheath of the flexor tendons. At the point of division into its four digital processes, the fascia is strengthened by transverse fibers forming the *superficial transverse ligament*. Through the spaces between the primary divisions of the fascia pass the digital vessels and nerves and the lumbricales tendons. This central portion of the palmar fascia is closely united to the skin of the palm by many small, short, fibrous bands, which prevent the integument from being thrown into folds and from gliding to and fro during the various movements of the hand. This connection of the skin and fascia is so intimate that pus cannot travel for any distance between them. It either burrows deeper or perforates the skin. From either side of the central portion a process of fascia dips into the palm to join the deep transverse

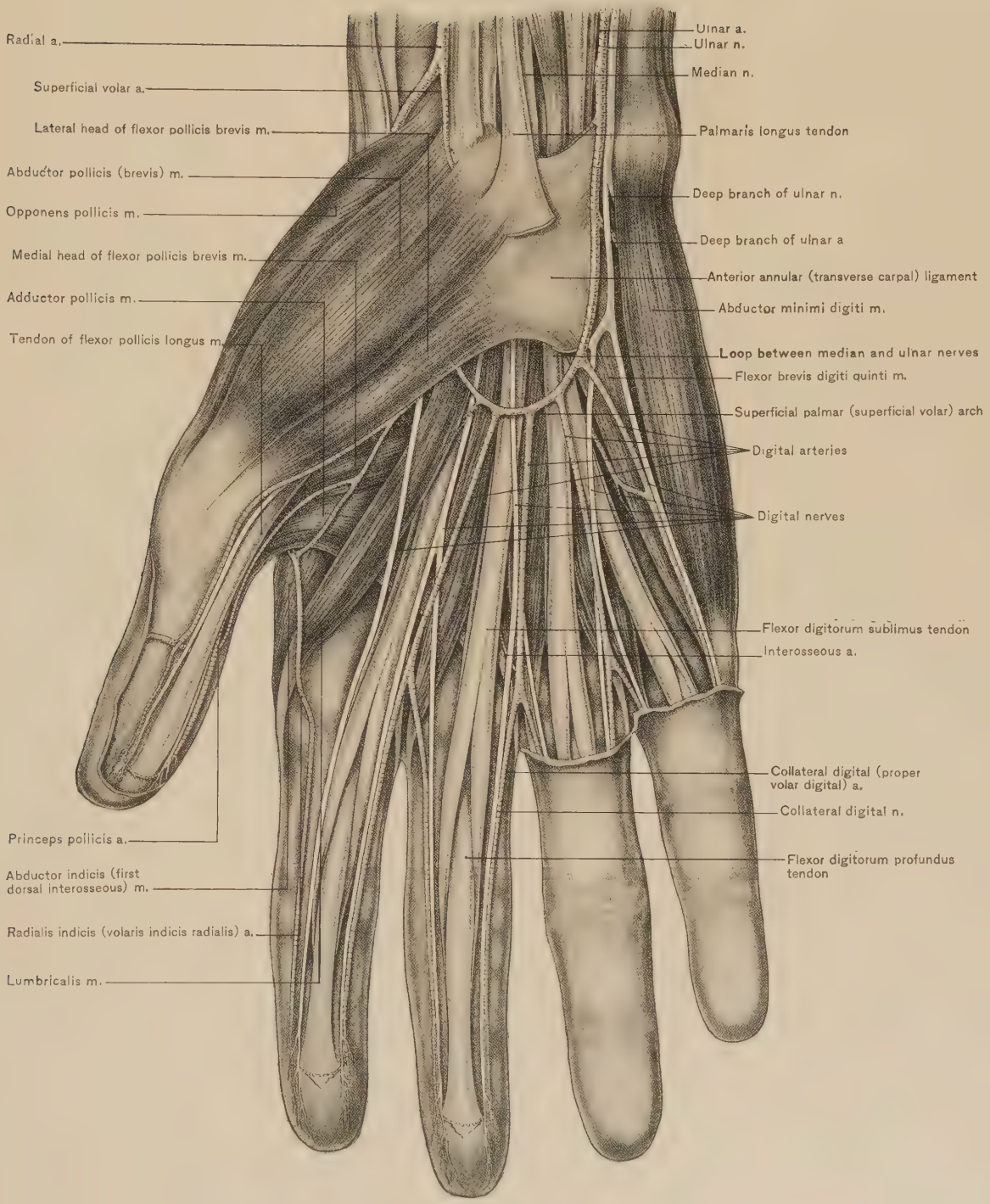
layer of fascia which covers the interossei muscles, the deep palmar (*deep volar*) arch, and the metacarpal bones, thus separating the muscles of the thenar and hypothenar eminences from the center of the palm. This central fascial compartment contains the superficial palmar (*superficial volar*) arch and its branches, the digital branches of the median nerve, the lateral digital branch of the ulnar nerve, the superficial and deep flexor tendons, and the lumbricales muscles. This fascial compartment, which is of much surgical significance, may be compared to a box, the open ends of which correspond to the tunnel under the anterior annular (*transverse carpal*) ligament, proximally, and to the intervals between the primary and secondary divisions of the central palmar fascia, distally. Owing to the density of this central palmar fascia a collection of pus in this compartment would point in the forearm above the anterior annular (*transverse carpal*) ligament, at the sides of the dense central palmar fascia, *e. g.*, the thenar and hypothenar eminences, at the clefts of the fingers, or upon the dorsum of the hand over the interosseous spaces, rather than in the center of the palm. Occasionally pus works toward the palmar surface through small gaps in the fascia, forming an hour-glass abscess which the French term *abcés en bissac*. The deep transverse layer of the palmar fascia offers some resistance to the passage of pus toward the dorsum of the hand. In incising palmar abscesses, it is safer to limit the incision to the skin and open the deeper structures by blunt dissection. The incision should not be any nearer to the wrist than a transverse line on a level with the web of the thumb because of the danger of cutting the superficial palmar (*superficial volar*) arch. (Plate CLXIV.) Contraction of the digital slip that passes to the ring or the little finger, flexes the finger upon the palm at the metacarpophalangeal joint and produces the deformity known as Dupuytren's contraction of the finger, in which case the fibrous band becomes prominent under the overlying skin, which often presents transverse folds over the contracted fascia. This condition can be relieved only by subcutaneous or open section of the offending slip or by a formal plastic operation.

The *lateral portions* of the palmar fascia are thin, and are continuous with the central palmar fascia and the fascia of the dorsum of the hand; they cover the muscles of the thenar and hypothenar eminences.

Dissection.—Divide the expansion of the palmaris longus and reflect the central palmar fascia toward the fingers, noting its deep processes located upon either side. The structures of the palm now exposed are: the superficial palmar (*superficial volar*) arch and its branches, the median nerve and its divisions, the superficial and deep flexor tendons, and the lumbricales muscles. Upon each side of the palm are the muscles composing the thenar and hypothenar eminences.

The **superficial palmar (superficial volar) arch** (Plate CLXV) is formed by the terminal part of the ulnar artery, and is completed by the superficial volar,

PLATE CLXV.


Radial a.
Superficial volar a.
Lateral head of flexor pollicis brevis m.
Abductor pollicis (brevis) m.
Opponens pollicis m.
Medial head of flexor pollicis brevis m.
Adductor pollicis m.
Tendon of flexor pollicis longus m.
Princeps pollicis a.
Abductor indicis (first dorsal interosseous) m.
Radialis indicis (volaris indicis radialis) a.
Lumbricalis m.
Ulnar a.
Ulnar n.
Median n.
Palmaris longus tendon
Deep branch of ulnar n.
Deep branch of ulnar a
Anterior annular (transverse carpal) ligament
Abductor minimi digiti m.
Loop between median and ulnar nerves
Flexor brevis digiti quinti m.
Superficial palmar (superficial volar) arch
Digital arteries
Digital nerves
Flexor digitorum sublimus tendon
Interosseous a.
Collateral digital (proper volar digital) a.
Collateral digital n.
Flexor digitorum profundus tendon

SUPERFICIAL PALMAR (SUPERFICIAL VOLAR) ARCH AND DIGITAL NERVES.

or a branch from the radialis indicis or princeps pollicis, and sometimes, though rarely, by a large median artery. It commences at the distal border of the pisiform bone, where the ulnar artery gives off the deep, or communicating, branch which passes backward between the abductor digiti quinti and flexor digiti quinti brevis muscles to complete the deep palmar (*deep volar*) arch. It curves across the palm to the thenar eminence, where it is joined by the branch or branches which complete it. The convexity of the arch is directed toward the fingers, its most distal point corresponding to a line drawn transversely across the hand from the distal border of the strongly abducted thumb. The superficial palmar (*superficial volar*) arch lies upon the short muscles of the little finger, the flexor tendons, and the digital branches of the median nerve, and is covered by the palmaris brevis, the palmar cutaneous branches of the median and ulnar nerves, and the central palmar fascia. Its branches are the four digital arteries.

The *digital branches* arise from the convexity of the arch; they supply the ulnar side of the little finger and the adjacent sides of the other fingers, except the thumb. The *first digital artery* is joined by a branch from the deep palmar arch and passes over the hypothenar eminence, to which it sends branches, and under the medial digital branch of the ulnar nerve. It supplies the ulnar side of the little finger. The *second*, *third*, and *fourth digital arteries* pass to the intervals between the fingers, where they are joined by the interosseous (*volar metacarpal*) branches of the deep palmar (*deep volar*) arch and the anterior (*distal*) perforating branches of the dorsal interosseous (*dorsal metacarpal*) arteries. Beneath the superficial transverse ligament, about six millimeters (one-fourth of an inch) proximal to the clefts of the fingers, they divide into two collateral, or proper, digital branches to supply the adjacent sides of the fingers. At their commencement they lie over the superficial flexor tendons, but as they approach the clefts of the fingers, they course between them, in company with the digital nerves, and also between the primary slips of the cental palmar fascia, together with the nerves superficial to the arteries. Since the digital arteries lie over the interosseous spaces, palmar abscesses should be opened in the line of the metacarpal bones. Upon the side of the finger the collateral digital artery is behind the nerve. The collateral digital arteries of each finger unite to form an arch across the front of the finger a little distal to the terminal joint, and from this arises an arterial plexus which supplies the pulp of the end of the finger and the matrix of the nail. Small twigs supply the interphalangeal joints, the integument, and the sheaths of the tendons, and form arterial plexuses, one in front of each joint.

The **ulnar nerve** crosses the wrist in front of the anterior annular (*transverse carpal*) ligament upon the ulnar side of the ulnar artery, between the artery and the pisiform and unciform (*hamatum*) bones; resting in a groove between these

bones it is protected from pressure. It divides into a superficial and a deep branch. The *superficial branch* passes along the ulnar side of the palm, supplying the skin of the hypothenar eminence, the ulnar surface of the palm and the palmaris brevis muscle. It divides into one communicating and two digital branches. The medial one, the *proper volar digital branch*, supplies the medial side of the little finger; the lateral one, the *common volar digital branch*, divides into collateral, or proper, digital branches to supply the adjacent sides of the little and ring fingers. The *communicating branch* joins the medial digital branch of the median nerve. The *deep branch* of the ulnar nerve accompanies the profunda branch of the ulnar artery, and passes backward between the abductor and flexor brevis digiti quinti muscles, through the opponens digiti quinti, and upon the distal side of the deep palmar (*deep volar*) arch.

It supplies the short muscles of the little finger, all of the interossei, the two ulnar lumbricales, the adductor pollicis, and the medial, or deep, head of the flexor pollicis brevis.

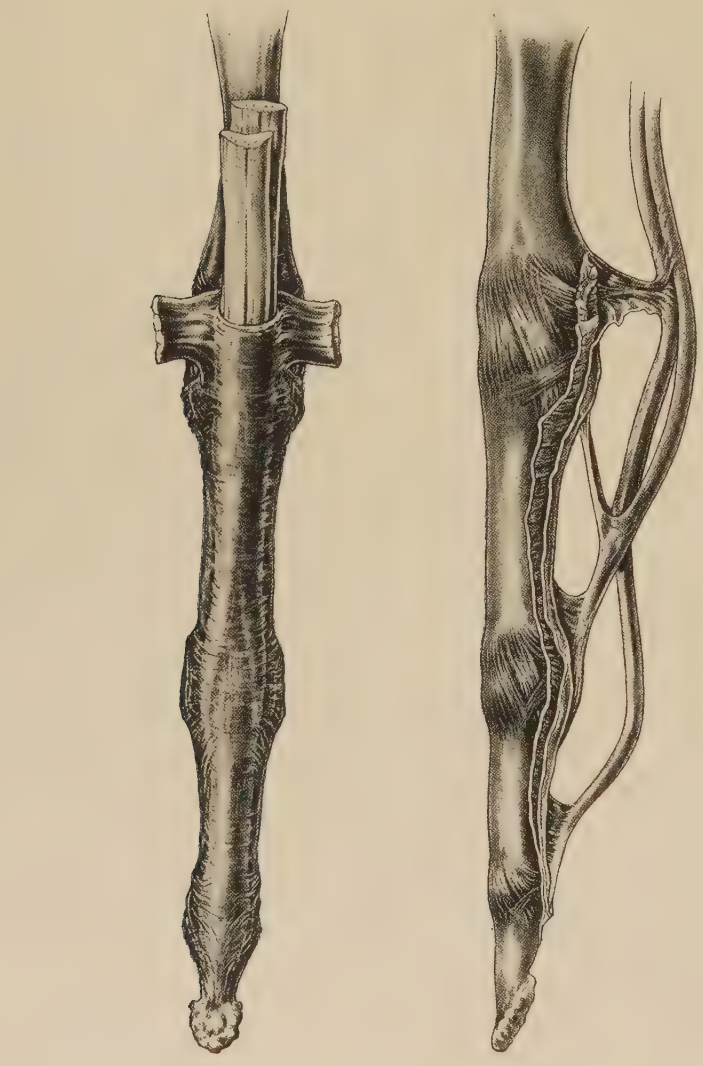
The **median nerve** enters the hand beneath the anterior annular (*transverse carpal*) ligament enveloped by the synovial sheaths of the flexor tendons of the hand; it rests upon the tendons, spreads out slightly, and, as it emerges from the ligament, bifurcates into a lateral and a medial division.

The *lateral division* gives off muscular branches to the abductor (*abductor pollicis brevis*) and the opponens pollicis and the lateral head of the flexor pollicis brevis; it then divides into two proper volar digital branches; the one supplies a collateral branch to the sides of the thumb, while the other goes to the radial side of the index finger and sends a small twig to the first lumbricales muscle.

The *medial division* divides into a lateral and a medial, or common, volar digital branch; the lateral sends a branch to the second lumbricales muscle and divides into two collateral, or proper digital, branches, which supply the adjacent sides of the index and middle fingers as well as the dorsum of these fingers. The medial, or proper, digital branch, in addition to communicating with the ulnar nerve, divides into two collateral, or proper, digital branches, which supply the adjacent sides of the middle and ring fingers, and also, occasionally, the third lumbricales muscle. Each collateral branch sends branches to the dorsum of the fingers, that of the middle finger being almost entirely supplied by these nerves.

At first the digital nerves are beneath the superficial palmar (*superficial volar*) arch and the digital branches arising therefrom, but they gradually become more superficial, and along the sides of the fingers lie in front of the collateral, or proper, digital arteries. At the tips of the fingers they give off volar twigs to supply the

PLATE CLXVI.



Great carpal bursa and thecae.

FIBROUS AND SYNOVIAL SHEATHS OF FLEXOR TENDONS.

pulp of the finger, and on the dorsal aspect, twigs which supply the matrix of the nail. Very careful dissection discovers upon the finer ramifications of the collateral branches of the digital nerves minute seed-like enlargements, known as Pacinian corpuscles.

The **flexor tendons** cross the wrist in a large compartment beneath the anterior annular (*transverse carpal*) ligament, the lateral one being that for the *flexor pollicis longus*, which passes lateralward along the thumb. The four tendons of the *flexor digitorum sublimis* lie in the tunnel beneath the anterior annular (*transverse carpal*) ligament, arranged in two pairs, one anterior to the other. The anterior pair go to the middle and ring fingers; the posterior, to the index and little fingers. Of the tendons of the *flexor digitorum profundus*, the one for the index finger is separated from the others; the remaining three are in close contact until after they enter the palm. Each flexor sublimis tendon is accompanied to the root of its respective finger by the corresponding deep flexor tendon which lies under it. The tendons of the deep flexor give origin to the lumbricales muscles. The flexor tendons are confined to the phalanges by fibrous sheaths, which must be laid open in order to expose the tendons.

The *fibrous sheaths* of the flexor tendons are subcutaneous. Upon each side of these sheaths are the collateral digital vessels and nerves. The sheaths are attached to the sharp lateral margins of the volar surface of the phalanges, and thus form an osteo-fibrous canal, composed of bone behind and fibrous tissue in front. The sheaths are thin at the joints and thick opposite the bodies of the phalanges, being especially thick opposite the proximal two phalanges (the first only of the thumb), at which point they are called the *vaginal ligaments*, their function being to keep the tendons close to the bones when the fingers are flexed. Throughout its entire length, each fibrous sheath is lined by a synovial membrane, which is reflected over the tendons, thus forming a tubular sac, or *theca*. The thecæ, or synovial sacs, of the index, middle, and ring fingers extend from the heads of the metacarpal bones to the middle of the distal phalanges, and these sacs, except those of the thumb and little finger, do not communicate with the carpal bursæ. The sac for the thumb communicates with the great carpal bursa proximal to the wrist, while that for the little finger is continuous with it (Plate CLXVI).

Upon the under surface of the flexor tendons, as they pass along the fingers, synovial reflections are found connecting them with the adjacent bone. Near the insertion of the tendon they are triangular, and are called *ligamenta brevia* (*vincula brevia*); longer, slender reflections, called *ligamenta longa* (*vincula longa*), make similar connections, but further from the insertion of the tendon. The two together are known as the *vincula accessoria*. These vincula carry

blood-vessels to the flexor tendons. Inflammation of the thecæ is known as thecitis. If the inflammation results in a purulent collection within the theca, it constitutes a superficial felon; while if the pus forms beneath the periosteal covering of the phalanx, a deep felon results. Superficial felons should be incised in the median line of the finger, so as to avoid the collateral digital arteries; while for a deep felon the incision should be made along the side of the tendon.

The *insertions* of the flexor tendons are as follows: each tendon of the flexor digitorum sublimis rests upon the corresponding tendon of the flexor digitorum profundus; opposite the metacarpo-phalangeal joints the tendons of the flexor sublimis broaden and opposite the middle of the proximal phalanges split into two segments, between which pass the tendons of the flexor profundus; they reunite and again divide, to be inserted into the middle of both sides of the second phalanges. The tendons of the flexor profundus, after perforating the tendons of the flexor sublimis, pass on for insertion into the front of the base of the distal phalanges. The tendon of the flexor pollicis longus passes between the two heads of the flexor pollicis brevis for insertion into the front of the base of the distal phalanx of the thumb.

The **lumbricales** (Plate CLXVII) are four slender, fleshy muscles which are accessory to the deep flexor tendons and connect these with the tendons of the extensor digitorum communis. They *arise* from the radial side of the deep flexor tendons of the index and middle fingers, and from the adjacent sides of the tendons of the middle, ring, and little fingers. Each muscle terminates in a delicate tendon, which passes around the radial side of the base of the proximal phalanx of the corresponding finger and is *inserted* into the tendon of the extensor digitorum communis upon the dorsum of the proximal phalanx. The lumbricales may vary in number, sometimes six and sometimes only two muscles being present.

Blood Supply.—From the digital branches of the superficial palmar (*superficial volar*) arch and the interosseous branches of the deep palmar (*deep volar*) arch.

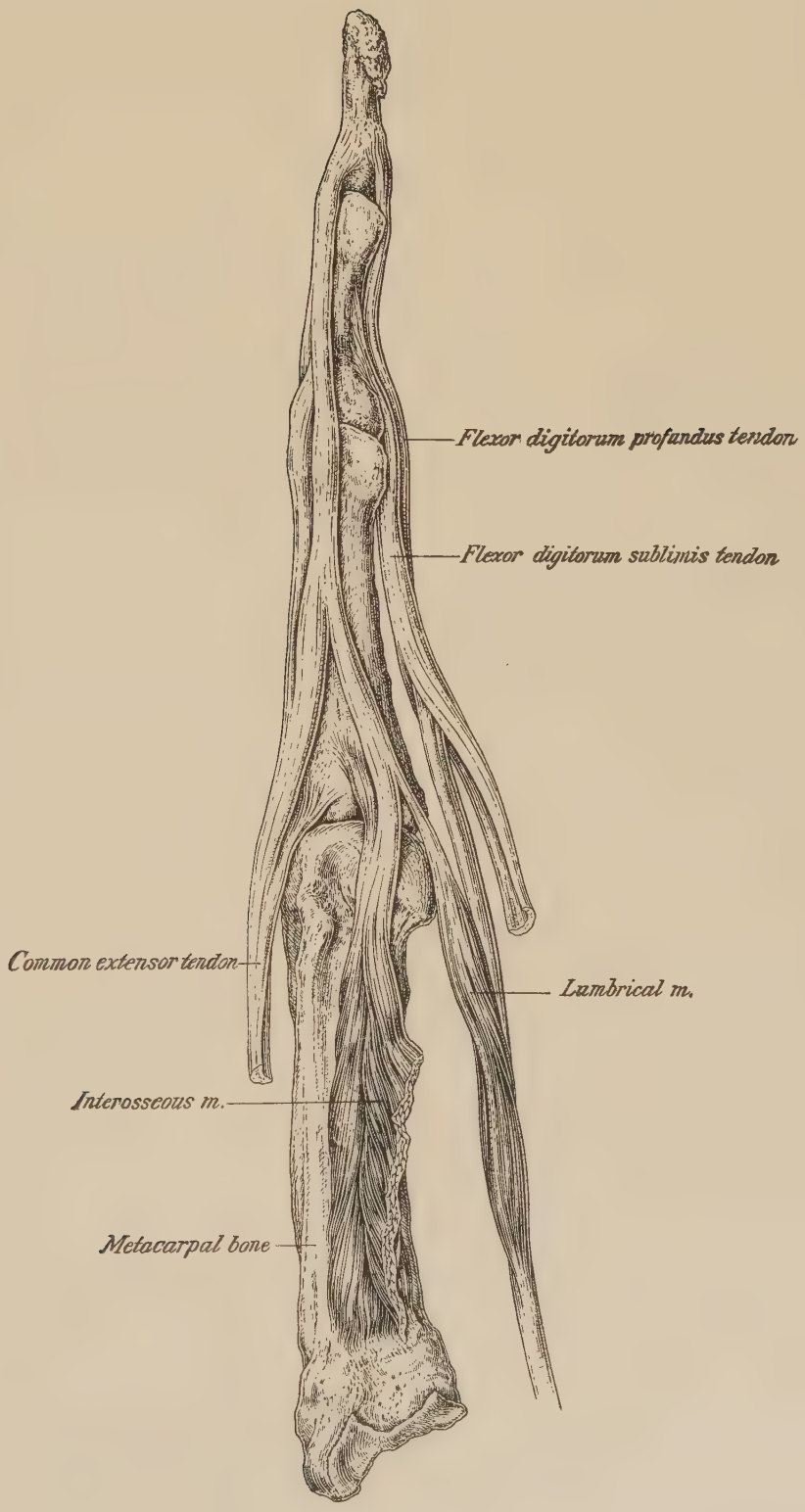
Nerve Supply.—From the median nerve for the two lateral lumbricales muscles and from the ulnar nerve for the two medial muscles.

Action.—Assist the flexor tendons in flexing the metacarpo-phalangeal joints, and the extensor tendons in extending the two interphalangeal joints.

Dissection.—Remove the lateral portions of the deep palmar fascia and separate the muscles of the thenar and hypothenar eminences.

The **thenar eminence,** or ball of the thumb, is composed of four muscles: the abductor pollicis (*abductor pollicis brevis*), opponens pollicis, flexor pollicis brevis, and adductor pollicis.

PLATE CLXVII.



INSERTION OF LUMBRICALES AND INTEROSSEOUS MUSCLES.

The **abductor pollicis** (**abductor pollicis brevis**), the most superficial muscle of the ball of the thumb, is a thin, flat muscle which *arises* from the front of the anterior annular (*transverse carpal*) ligament and the trapezium (*multangulum majus*). It is *inserted* into the radial side of the base of the proximal phalanx of the thumb and the tendon of the extensor secundi internodii pollicis (*extensor pollicis longus*) over the proximal phalanx. It rests upon the opponens pollicis and the superficial, or lateral, head of the flexor pollicis brevis.

Blood Supply.—From the superficial volar artery.

Nerve Supply.—From the median nerve.

Action.—It abducts the thumb and assists in extension of the distal phalanx.

Dissection.—Cut the muscle transversely at its middle, and reflect it.

The **opponens pollicis** is small and triangular, and is subcutaneous in its lateral part, while its medial portion is covered by the abductor pollicis (*abductor pollicis brevis*). It *arises*, beneath the abductor, from the front of the anterior annular (*transverse carpal*) ligament and the trapezium (*multangulum majus*), whence its fibers diverge for *insertion* into the radial side of the entire length of the metacarpal bone of the thumb. It is covered by the abductor pollicis (*abductor pollicis brevis*) and the deep fascia, and lies upon the joint between the trapezium (*multangulum majus*) and the metacarpal bone of the thumb and on the radial side of the superficial head of the flexor pollicis brevis.

Blood Supply.—From the radial and superficial volar arteries.

Nerve Supply.—From the median nerve.

Action.—To adduct the thumb and oppose it to the other fingers.

The **flexor pollicis brevis** arises by a superficial and a deep head, between which passes the tendon of the flexor pollicis longus. The *superficial head arises* from the lower border of the anterior annular (*transverse carpal*) ligament and the trapezium (*multangulum majus*); the *deep head* (sometimes described as a separate muscle, and called the oblique adductor of the thumb) *arises* from the bases of the first, second, and third metacarpal bones, from the trapezoid (*multangulum minus*) and os magnum (*os capitatum*), and the sheath of the tendon of the flexor carpi radialis. The fibers from these origins unite and then separate for *insertion* into each side of the base of the proximal phalanx of the thumb. Each tendon of insertion contains a sesamoid bone where it passes over the metacarpo-phalangeal joint; the tendon of the superficial head is joined by the tendon of the abductor pollicis (*abductor pollicis brevis*), and that of the deep head by the tendon of the adductor pollicis. The superficial head lies in contact with the ulnar border of the opponens pollicis, and is covered by the abductor pollicis (*abductor pollicis brevis*) and the deep fascia. It rests upon the opponens pollicis, the tendon of the flexor pollicis longus, and the deep head. The deep head is covered

by the flexor tendons of the index and middle fingers and the two lateral lumbricales. It rests upon the deep palmar (*deep volar*) arch, the muscles of the first two interosseous spaces, the tendon of the flexor carpi radialis, and the radialis indicis (*volar indicis radialis*) artery.

Blood Supply.—From the radial artery.

Nerve Supply.—From the median nerve.

Action.—It flexes the carpo-metacarpal and metacarpo-phalangeal joints of the thumb. The deep head is also an oblique adductor, aiding the contiguous adductor pollicis in drawing the head of the metacarpal bone of the thumb toward the pisiform bone.

The **adductor pollicis,** the deepest muscle of this group, is triangular in shape, and is separated into two parts by the radial artery. It *arises* by its base from the front of the metacarpal bone of the middle finger, whence its fibers converge for *insertion* into the ulnar side of the base of the proximal phalanx of the thumb, in common with the deep tendon of the flexor pollicis brevis. It is covered by the ulnar border of the deep head of the flexor pollicis brevis, the two lateral tendons of the flexor digitorum sublimis and flexor digitorum profundus muscles, and the two lateral lumbricales. It lies upon the radialis indicis (*volar indicis radialis*) artery, the first dorsal interosseous muscle, and the interosseous muscles of the second interosseous space.

Blood Supply.—From branches from both palmar (*volar*) arches.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—It adducts the thumb, approximating it to the index finger.

The **hypothenar eminence** is the fleshy prominence upon the ulnar side of the palm of the hand. It is composed of the palmaris brevis, the abductor digiti quinti, the flexor brevis digiti quinti and the opponens digiti quinti; the last three are the short muscles of the little finger. The palmaris brevis is described on p. 139.

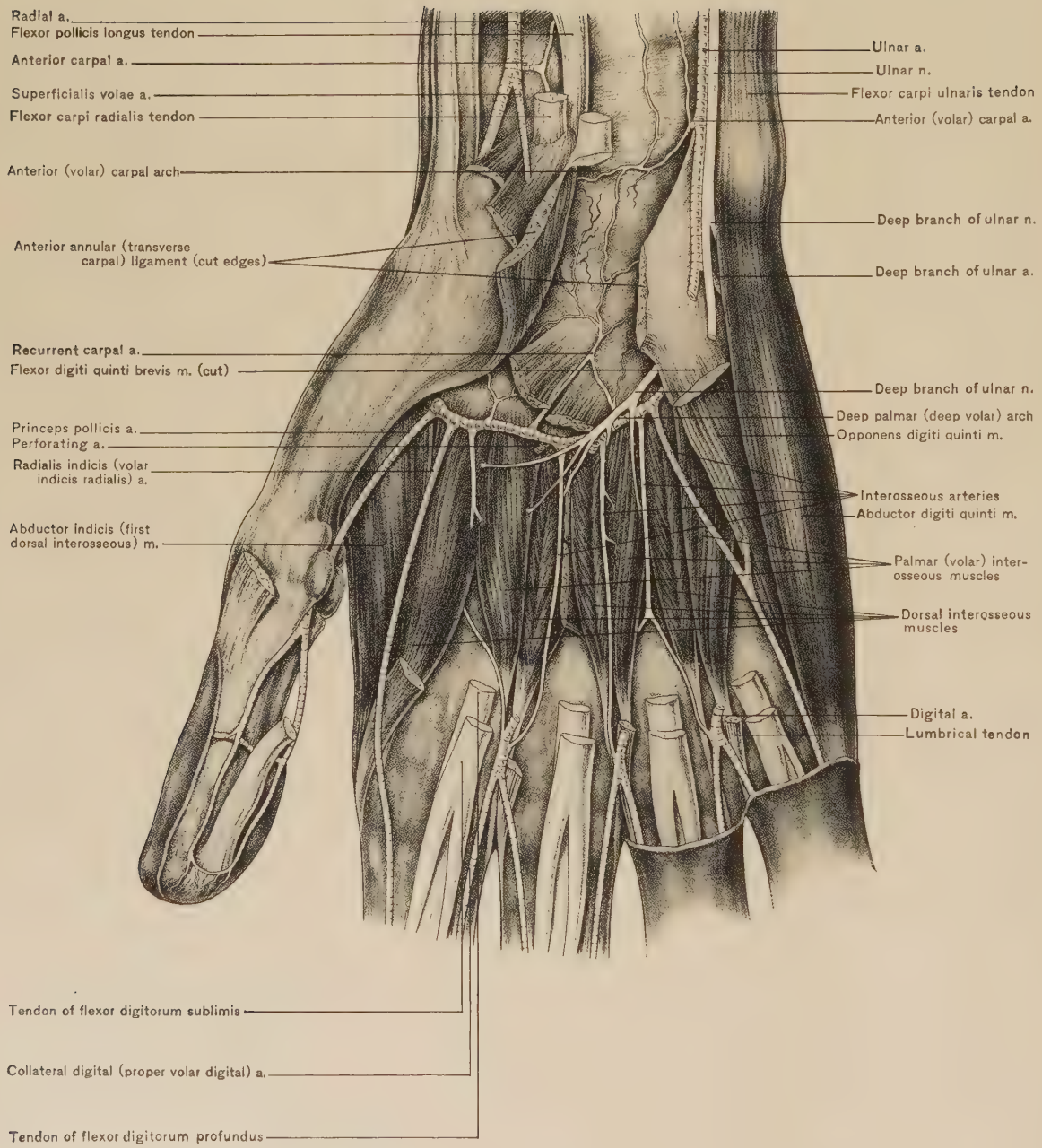
The **abductor digiti quinti** lies upon the ulnar side of the hypothenar eminence, and *arises* from the pisiform bone and an expansion of the tendon of the flexor carpi ulnaris. It is *inserted* by a flattened tendon into the ulnar side of the base of the first phalanx of the little finger and into the same side of the tendon of the extensor minimi digiti (*extensor digiti quinti proprius*). It is subcutaneous, except at its base, where it is covered by the palmaris brevis. Its rests upon the opponens digiti quinti on the ulnar side of the flexor brevis digiti quinti.

Blood Supply.—From the ulnar artery.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—It abducts the little finger, flexes the metacarpo-phalangeal articulation, and extends the interphalangeal joints of that finger.

PLATE CLXVIII.



DEEP PALMAR (DEEP VOLAR) ARCH AND INTEROSSEOUS MUSCLES.

The **flexor brevis digiti quinti** lies upon the radial side of the preceding muscle and *arises* from the anterior annular (*transverse carpal*) ligament and the hook of the unciform bone (*os hamatum*). It is *inserted*, with the preceding muscle, into the ulnar side of the base of the proximal phalanx of the little finger. It is subcutaneous, except where it is covered by the palmaris brevis. It rests upon the opponens digiti quinti.

Blood Supply.—From the ulnar artery.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—It flexes the metacarpo-phalangeal joint of the little finger.

The **opponens digiti quinti** is triangular in form and corresponds to the opponens pollicis. It *arises* at its apex from the anterior annular (*transverse carpal*) ligament and the hook of the unciform bone (*os hamatum*), whence its fibers diverge for *insertion* into the entire length of the ulnar margin of the metacarpal bone of the little finger. It is covered by the two preceding muscles, and rests upon the interosseous muscles of the fourth interspace, the metacarpal bone, and the deep branches of the ulnar artery and nerve.

Blood Supply.—From the ulnar artery.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—It draws the head of the metacarpal bone of the little finger forward and toward the radial side of the hand, aiding in hollowing the palm and in approximating the little finger to the thumb.

Dissection.—Divide the anterior annular (*transverse carpal*) ligament and the flexor tendons; reflect the latter, with the lumbricales muscles, downward, and expose the deep transverse layer of fascia which covers the deep palmar (*deep volar*) arch, the deep branch of the ulnar nerve, the interossei muscles, and the metacarpal bones. Remove the deep transverse layer of fascia and trace the vessels and nerve beneath it. Next, sever the adductor pollicis and the deep head of the flexor pollicis brevis at their origins, and reflect them in order to expose the remainder of the deep palmar (*deep volar*) arch and the origins of the princeps pollicis and the radialis indicis (*volaris indicis radialis*) arteries.

The **deep palmar** (**deep volar**) **arch** (Plate CLXVIII) is the terminal portion of the radial artery. It begins at the entrance of the radial artery into the palm between the two heads of the first dorsal interosseous muscle. It then passes between the adductor pollicis and the ulnar head of the flexor pollicis brevis, when it arches, with its convexity distally, over the bases of the metacarpal bones and the palmar (*volar*) interosseous muscles to the base of the metacarpal bone of the little finger, where it is completed by joining the deep branch of the ulnar artery. It is less curved than the superficial arch and is situated one and a quarter centimeters

(one half inch) nearer the wrist. It is accompanied by the deep branch of the ulnar nerve.

The *branches* of the deep palmar (*deep volar*) arch from its convexity are: the princeps pollicis, the radialis indicis (*volaris indicis radialis*), the palmar interosseous (*volar metacarpal*), and the superior perforating, and from the concavity of the arch, the recurrent carpal arteries. (Plate CLXIX.)

The **princeps pollicis artery,** a branch of uncertain origin, arises separately or by a common trunk with the radialis indicis (*volaris indicis radialis*) from the arch, close to the interval between the two heads of the first dorsal interosseous muscle. It first passes between the first dorsal interosseous muscle and the flexor pollicis brevis, then between the two heads of the latter along the metacarpal bone of the thumb, under cover of the tendon of the flexor pollicis longus, to the base of the first phalanx, where it divides into two collateral branches which descend upon the sides of the thumb, with the tendon of the flexor pollicis longus between them. They terminate in an arch similar to that formed by the collateral arteries of the fingers.

The **radialis indicis** (**volaris indicis radialis**) **artery** is given off near the preceding artery. It passes between the first dorsal interosseous muscle and the adductor pollicis along the palmar aspect of the radial border of the index finger. It often anastomoses with the superficial palmar arch.

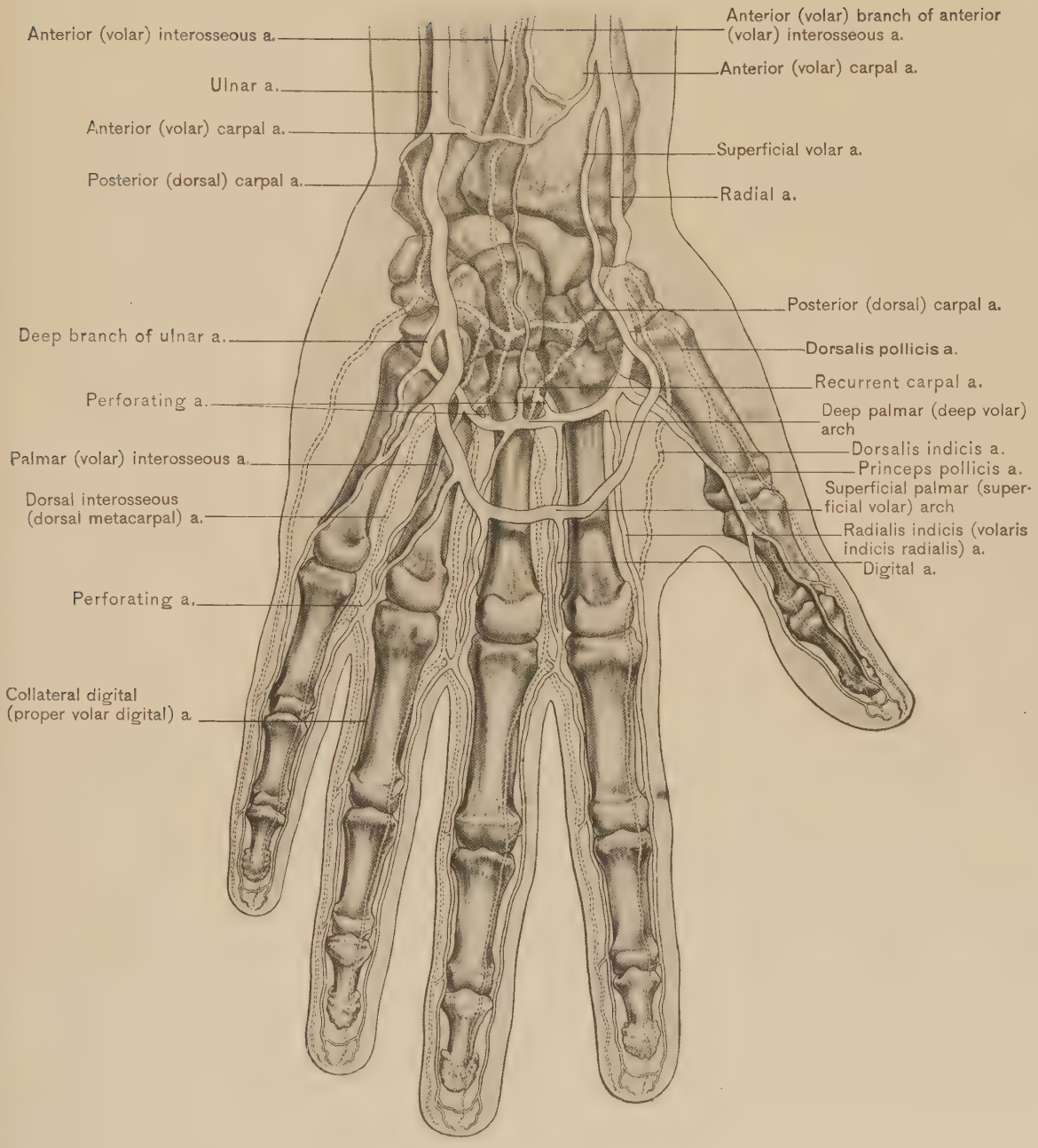
The **palmar interosseous** (**volar metacarpal**) **arteries,** three in number, pass distally over the interosseous muscles in the second, third, and fourth interosseous spaces, to join the corresponding digital branches of the superficial palmar (*superficial volar*) arch just before they divide into the collateral digital arteries.

The **superior** (**proximal**) **perforating arteries,** three in number, pierce the proximal ends of the three medial interosseous spaces, and pass between the heads of the dorsal interosseous muscles to join the dorsal interosseous (*dorsal metacarpal*) arteries.

The **recurrent carpal arteries,** two or three in number, pass proximally in front of the wrist to join branches of the anterior (*volar*) carpal arch and the anterior branch of the anterior (*volar*) interosseous artery.

When one of the palmar (*volar*) arches is wounded, the resulting hemorrhage should be controlled by pressure upon the radial and ulnar arteries, and the wound cleansed. The artery should be completely severed, for a partially divided artery presents a gaping wound and contraction and retraction of the cut ends are thus prevented. If possible, without making a large wound, both bleeding ends should be tied in the wound. A large scar in the palm is a source of danger, because it may lead to contraction of the palmar fascia. When it is not

PLATE CLXIX.



ARTERIES OF HAND.

possible to ligate the bleeding ends a compress should be used. This may be made by placing a small piece of dry sterile gauze upon the bleeding points in the bottom of the wound and then adding successively larger sections of dry gauze. The metacarpal bones supply the requisite counterpressure.

The **palmar** (**volar**) **interossei** are three slender **muscles,** the *first* of which *arises* from the ulnar side of the metacarpal bone of the index finger and is *inserted* into the base of the proximal phalanx and the extensor tendon of the same finger; the *second arises* from the radial side of the metacarpal bone of the ring finger, and is *inserted* into the base of the proximal phalanx and the extensor tendon upon the same side of this finger; the *third* has a similar *origin* and *insertion* upon the radial side of the little finger.

Blood Supply.—From the deep palmar (*deep volar*) arch.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—They adduct the fingers to which they are attached, flex the respective metacarpo-phalangeal joints, and extend the two distal phalanges.

Note: The muscles of the upper extremity which are seen in dissecting the back are: the trapezius, rhomboidei, latissimus dorsi, supraspinatus, infraspinatus, teres major, teres minor, subscapularis, and serratus magnus (*serratus anterior*). They are described under the dissection of the back of the neck, shoulder, and back.

THE BACK OF THE ARM

Dissection.—With the body lying face downward, abduct the arm to a right angle with the trunk. If the body is placed upon its back, the forearm should be flexed upon the arm and the arm adducted across the upper part of the chest so that the elbow will be opposite the neck. Fix the arm in this position by means of hooks. Continue the transverse incision, made on the proximal part of the front of the forearm, around the back of the forearm, and reflect the skin toward the shoulder. In removing the superficial fascia, which is best done from without inward, trace the superficial nerves when reflecting the fascia. The nerves which supply the skin and superficial fascia of the back of the arm are, latero-medialward: the inferior external cutaneous branch (*distal branch of dorsal cutaneous of forearm*) of the musculo-spiral (*radial*), the terminal portion of the lower branch of the circumflex (*axillary*), the intercosto-humeral, the lesser internal cutaneous (*medial cutaneous of arm*), and the internal cutaneous (*posterior cutaneous of arm*) of the musculo-spiral (*radial*).

Before dissecting out the superficial nerves, note the bursa found over the olecranon. It is generally of considerable size, and if distended, may be very

prominent, constituting what is known as "miner's elbow." Other bursæ may sometimes be found over the medial and lateral condyles (*epicondyles*) of the humerus, and, lower down, upon the ulna and over its styloid process.

The **inferior external cutaneous branch** (**dorsal cutaneous nerve of forearm**) of the musculo-spiral (*radial*) nerve (Plate CXLVIII) becomes superficial upon the lateral side of the arm below the insertion of the deltoid, and then passes backward and distally behind the lateral humeral condyle (*epicondyle*) to the forearm. The **terminal portion of the lower branch of the circumflex** (**axillary**) **nerve** pierces the deep fascia, and supplies the skin over the lower part of the posterior surface of the deltoid muscle and the long head of the triceps.

The **intercosto-humeral** (**intercosto-brachial**) **nerve** passes down the arm, upon the medial side of the internal cutaneous branch (*posterior cutaneous nerve of arm*) of the musculo-spiral (*radial*) nerve, to supply the skin of the medial and back part of the arm.

The **lesser internal cutaneous nerve** (**medial cutaneous nerve of arm**) turns toward the back of the arm, above the medial condyle (*epicondyle*), descending to the medial side of the olecranon.

The **internal cutaneous branch** (**posterior cutaneous nerve of arm**) of the musculo-spiral (*radial*) nerve emerges from the axilla at the lateral end of the posterior fold, and passes distally along the medial and back part of the arm toward the elbow, supplying the area of skin behind that supplied by the intercosto-humeral (*intercosto-brachial*) nerve.

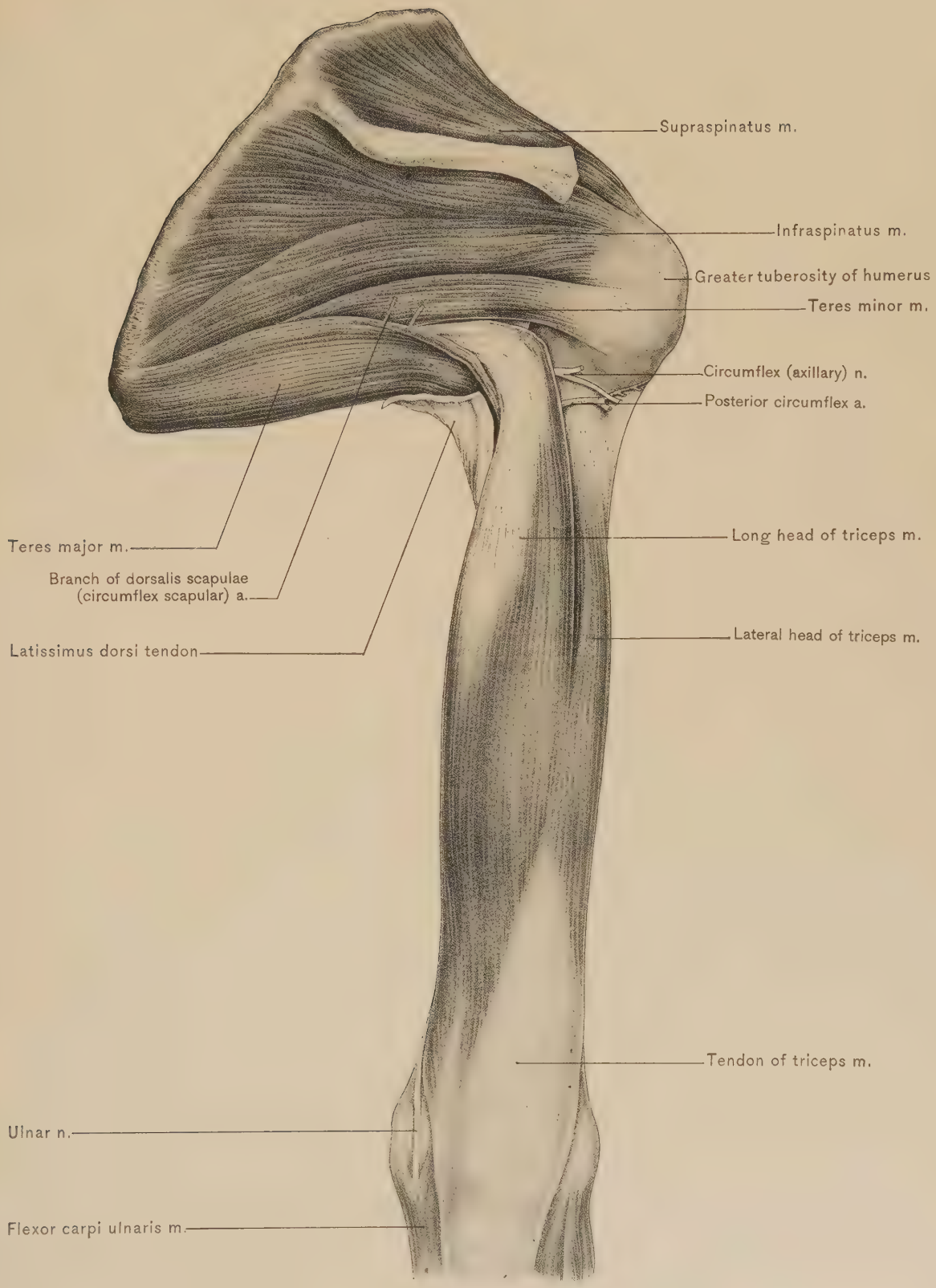
Deep fascia.—Next remove the deep fascia in the same manner as the superficial fascia. The deep fascia on the back of the arm is a continuation of that covering the front of the arm. It is closely attached to the tendon of the triceps and the bony prominences of the elbow.

The **triceps brachii** (Plate CLXX) is the main **muscle** on the back of the arm and the sole extensor of the forearm. It derives its name from the fact that it has three heads.

The **long head** *arises* by a flat tendon from a triangular depression on the axillary border of the scapula, immediately below the glenoid cavity; it blends with the glenoid (*labrum glenoidale*) and capsular ligaments; the long head of the biceps is similarly attached at the upper margin of the same cavity. As it passes between the teres major and minor muscles it becomes fleshy.

The **lateral head** *arises* from the posterior surface of the shaft of the humerus, proximal and lateral to the musculo-spiral (*radial*) groove, and from the lateral intermuscular septum to the point where it is pierced by the musculo-spiral (*radial*) nerve. The surface of origin extends as high as the insertion of the teres minor.

PLATE CLXX.



POST-SCAPULAR MUSCLES AND TRICEPS BRACHII MUSCLE.

The **medial head** *arises* from the back of the shaft of the humerus distal and medial to the musculo-spiral (*radial*) groove, the medial intermuscular septum and the lateral intermuscular septum below the point where it is pierced by the musculo-spiral (*radial*) nerve. The surface of origin extends upward as far as the insertion of the teres major into the posterior bicipital ridge and distally to within one centimeter (*one-half inch*) of the proximal edge of the olecranon fossa.

Tendon of insertion.—The long head becomes tendinous in the distal third of the arm where it is joined on the lateral side by the lateral head. The greater part of the medial head is attached to the under surface and each side of this tendon. The deeper fibers of the medial head are *inserted* directly into the olecranon and the posterior ligament of the elbow-joint. The common tendon, which is *inserted* into the summit and the sides of the olecranon, is continuous with the deep fascia of the forearm upon each side. A small bursa separates the tendon of the triceps brachii from the posterior ligament of the elbow-joint and the proximal end of the olecranon.

The long head, in its descent from the scapula, passes between the teres minor behind and the teres major in front, and assists in forming a quadrangle which is bounded by the humerus laterally, the teres minor proximally, the long head of the triceps medially, and the teres major distally; a triangle is found just below, bounded proximally by the teres minor and subscapularis, distally by the teres major, and laterally by the long head of the triceps. The quadrangle transmits the posterior circumflex vessels and the circumflex (*axillary*) nerve, and the triangle, the dorsalis scapulæ (*circumflex scapular*) vessels.

The posterior surface of the triceps brachii is subcutaneous, except at its proximal end, where it is covered by the deltoid. The anterior surface is in relation with the humerus, the musculo-spiral (*radial*) nerve, the superior profunda (*profunda brachii*) vessels, and the elbow-joint. The long head lies in front of the deltoid and the teres minor, and behind the subscapularis, latissimus dorsi, and teres major muscles.

Blood Supply.—From the superior profunda (*profunda brachii*) and inferior profunda (*superior ulnar collateral*), the anastomotica magna (*inferior ulnar collateral*), and muscular branches of the brachial artery.

Nerve Supply.—From the musculo-spiral (*radial*) nerve.

Action.—It extends the forearm and adducts the humerus. The long head, by preventing downward luxation of the head of the humerus, forms a protection to the shoulder-joint.

The **subanconeus** is a very small muscle bearing the same relation to the triceps brachii and the elbow-joint as the subcrureus (*articularis genu*) does to the

crureus (*vastus intermedius*) muscle and the knee-joint. It consists of those fibers of the medial head of the triceps which are inserted into the posterior ligament of the elbow-joint.

Blood and Nerve Supply.—The same as that of the triceps brachii.

Action.—It draws the posterior ligament upward during the relaxation accompanying extension of the elbow and prevents pinching of the synovial membrane.

The **musculo-spiral (radial) nerve** (Plate CLXXI) is best observed on the back of the arm, after division of the long and lateral heads of the triceps muscle over the musculo-spiral (*radial*) groove, when the branches given off to the triceps can be traced. From the branch to the medial head a small nerve, accompanied by the posterior articular branch from the superior profunda (*profunda brachii*) artery, may be seen passing distally under cover of the lateral edge of the tendon, from beneath which it emerges between the olecranon and the lateral condyle (*epicondyle*) of the humerus to enter and supply the anconeus muscle. Owing to its proximity to the bone, the musculo-spiral (*radial*) nerve may be injured in fractures, or it may become involved in the resulting callus.

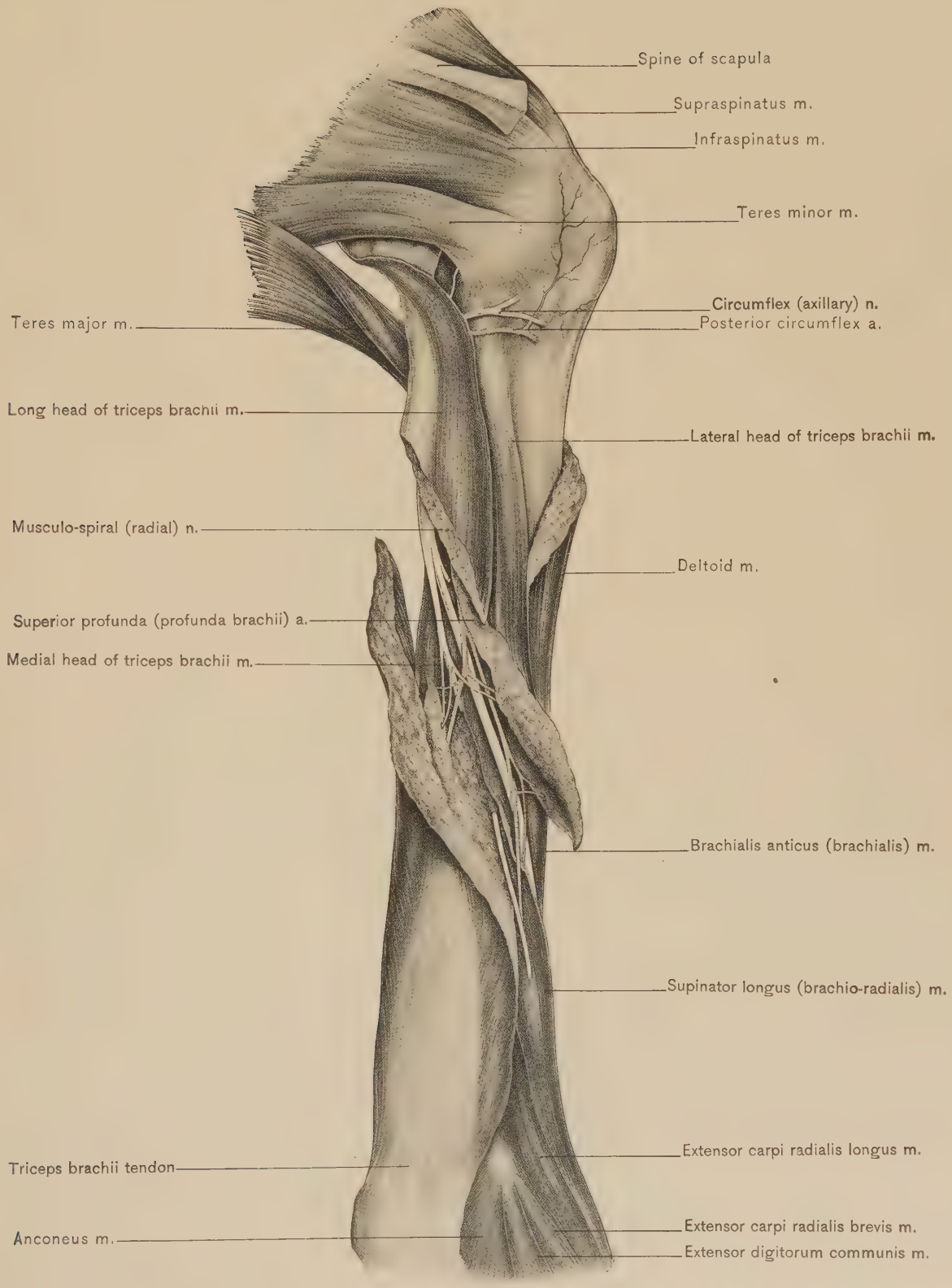
The **superior profunda (profunda brachii) artery,** lying in the groove with the musculo-spiral (*radial*) nerve, is exposed by the same dissection. As it emerges from under the lateral edge of the triceps it sends off a superficial branch, the *posterior articular*, to the elbow, after which it divides into two branches, one passing between the triceps and the bone to anastomose with the interosseous recurrent and anastomotica magna (*inferior ulnar collateral*) arteries, the other extending distally, between the supinator longus and the brachialis, to join the radial recurrent artery.

THE BACK OF THE FOREARM

Dissection.—Reflect the skin from the back of the forearm and hand as far as the roots of the fingers, and sever it at this point. Next incise the skin of the fingers in the median line and reflect it laterally. By reflecting the skin of the dorsum of the hand and fingers at the same time, a better opportunity is given for studying the superficial structures. The superficial fascia is now exposed. It contains the superficial veins, lymphatics, and nerves.

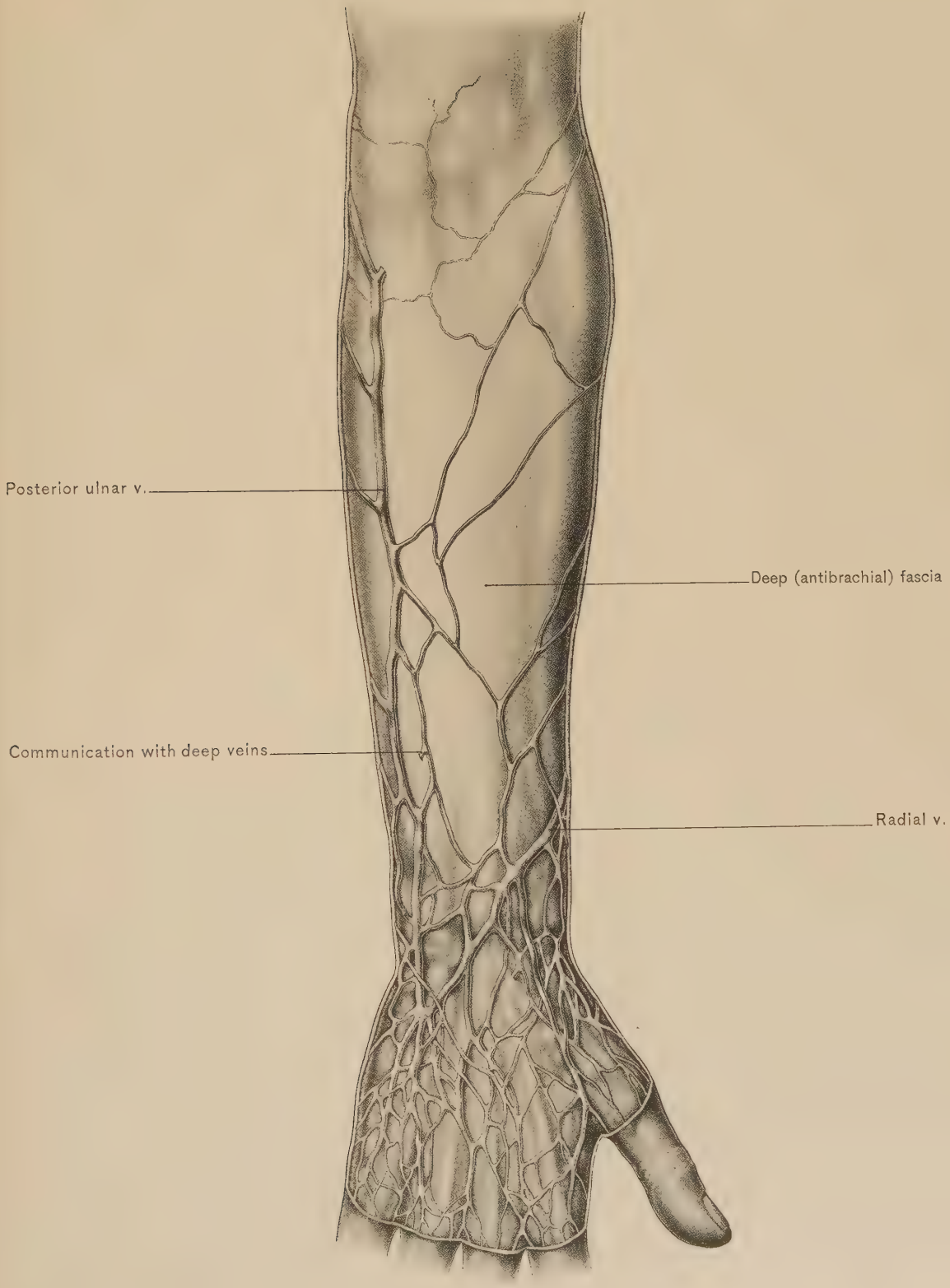
The **veins** (Plate CLXXII) of the back of the forearm and hand, which should be dissected out before removing the superficial fascia, are the radial (*cephalic*) and the anterior and the posterior ulnar (*basilic*). The radial (*cephalic*) and anterior ulnar (*basilic*) pass to the front of the forearm just above the wrist, while the posterior ulnar (*basilic*) continues on the back of the forearm almost as far as the elbow. These veins commence on the back of the hand in a plexus which

PLATE CLXXI.



MUSCULO-SPIRAL (RADIAL) NERVE AND SUPERIOR PROFUNDA (PROFUNDA BRACHII) ARTERY.

PLATE CLXXII.



SUPERFICIAL VEINS OF BACK OF FOREARM AND HAND.

receives the veins of the fingers, the radial (*cephalic*) vein arising from the lateral side, and the anterior and posterior ulnar (*basilic*) from the medial side of the plexus. The veins of the fingers commence in a plexus situated around the matrix of the nail.

The **lymphatics** on the back of the fingers terminate in a plexus on the dorsum of the hand, from which vessels pass up the dorsum of the forearm and around the radial and ulnar borders to join those on the anterior surface.

The superficial **nerves** seen upon the back of the forearm and hand are: the posterior branch of the musculo-cutaneous, the inferior external cutaneous (*dorsal cutaneous of forearm*) branch of the musculo-spiral (*radial*), the lesser internal cutaneous (*medial cutaneous of arm*), the posterior branch of the internal cutaneous (*medial cutaneous of forearm*), the radial, and the dorsal cutaneous branch of the ulnar.

The **posterior branch** of the musculo-cutaneous nerve passes to the back of the forearm over the prominence formed by the supinator longus (*brachio-radialis*) and extensores carpi radialis longus and brevis muscles; it supplies the skin on the distal two-thirds of the back and the radial part of the forearm as far as the wrist, and communicates with a branch of the radial and the inferior external cutaneous branch (*distal branch of dorsal cutaneous nerve of forearm*) of the musculo-spiral (*radial*).

The **inferior external cutaneous branch** (**distal branch of dorsal cutaneous nerve of forearm**) of the musculo-spiral (*radial*) nerve enters the forearm in front of the lateral condyle (*epicondyle*) of the humerus, supplies the skin on the radial posterior part of the forearm, and terminates on the back of the hard. It communicates with the cutaneous branch of the musculo-cutaneous about the middle of the forearm.

The **lesser internal cutaneous nerve** (**medial cutaneous nerve of arm**) terminates in the skin upon the ulnar side of the olecranon, and communicates with the internal cutaneous nerve (*medial cutaneous nerve of forearm*).

The **posterior** (**ulnar**) **branch of the internal cutaneous nerve** (**medial cutaneous nerve of forearm**) enters the back of the forearm below the medial condyle (*epicondyle*) of the humerus, and supplies the skin over the ulnar posterior part of the forearm from the elbow to the wrist. It communicates with the dorsal branch of the ulnar nerve.

The **radial** (**superficial branch of radial**) **nerve** reaches the back of the forearm about seven and a half centimeters (three inches) proximal to the wrist, by passing under the tendon of the supinator longus (*brachio-radialis*) muscle. Near the distal end of the radius it gives off a *palmar cutaneous branch* which supplies the radial margin of the hand and the thumb, and then divides into

four branches. Of these, one supplies the ulnar side of the thumb, another passes to the radial side of the index finger, a third divides into two branches to supply the adjacent sides of the index and middle fingers, and a fourth communicates with a branch from the dorsal branch of the ulnar to supply the contiguous margins of the middle and ring fingers.

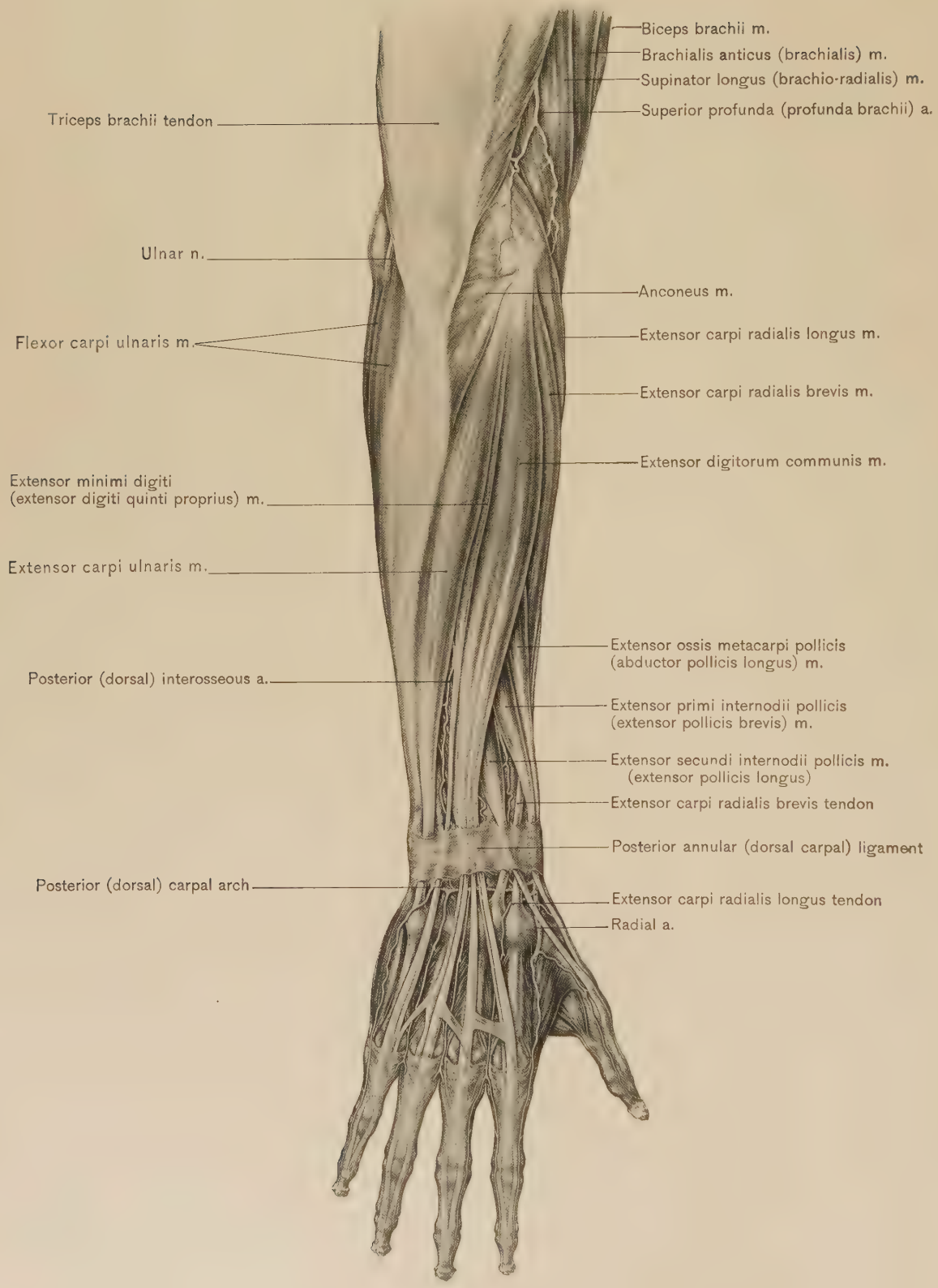
The **dorsal cutaneous branch of the ulnar nerve.**—At about seven and a half centimeters (three inches) above the wrist the ulnar nerve gives off a dorsal cutaneous branch, which passes backward under the flexor carpi ulnaris and over the tendon of the extensor carpi ulnaris to the back of the wrist, where it divides into one communicating and two digital branches. The medial digital branch passes to the ulnar side of the little finger, while the lateral digital branch passes to the middle of the fourth interosseous space, where it divides into two branches which supply the adjacent sides of the little and ring fingers. The communicating branch joins a filament from the radial (*superficial branch of radial*) nerve, and aids in the supply of the contiguous sides of the ring and middle fingers.

The **deep fascia** of the back of the forearm is stronger than that of the front. It is attached proximally to the lateral and medial condyles (*epicondyles*) of the humerus and the olecranon, where it receives expansions from the bicipital fascia (*lacertus fibrosus*) and the tendon of the triceps; it is also attached to the posterior border of the ulna, the lateral border of the distal end of the radius, the pisiform bone and the cuneiform bone (*os triquetrum*). At the wrist the deep fascia is very dense, contains many transverse fibers, and forms the posterior annular (*dorsal carpal*) ligament, beyond which it is continued upon the back of the hand as a delicate membrane.

Dissection.—Incise the deep fascia transversely above the posterior annular (*dorsal carpal*) ligament, and reflect it from below upward, as it is very firmly attached to the muscles in the proximal part of the forearm. The posterior annular (*dorsal carpal*) ligament should be left in place so that the relations of the underlying structures can be studied.

The **posterior annular (dorsal carpal) ligament** is that thickened portion of the deep fascia of the forearm which extends obliquely medialward from the lateral border of the distal end of the radius to the pisiform bone and the cuneiform bone (*os triquetrum*), and is continuous with the deep fascia of the hypothenar eminence. From the under surface vertical processes are given off which are attached to ridges on the posterior surface of the distal end of the radius. By means of these processes six *compartments* are formed for the passage of the extensor tendons of the following muscles in their order mediolaterally: the extensor carpi ulnaris, the extensor minimi digiti (*extensor digiti quinti proprius*),

PLATE CLXXIII.



SUPERFICIAL MUSCLES OF BACK OF FOREARM.

the extensor digitorum communis and extensor indicis (*extensor indicis proprius*), the extensor secundi internodii pollicis (*extensor pollicis longus*), the extensores carpi radialis longus and brevis, the extensor primi internodii pollicis (*extensor pollicis brevis*), and extensor ossis metacarpi pollicis (*abductor pollicis longus*). Each compartment has a synovial lining which extends above and below the limits of the ligament. The sheaths of the extensor tendons, particularly those of the thumb, are frequently the site of inflammation, tenosynovitis, which causes a longitudinal swelling over the position of the tendon, due to increased secretion in the synovial sheath. There is also a grating or crepitant sensation communicated to the surgeon's finger when the patient contracts the muscles (*tenalgia crepitans*). Tuberculous tenosynovitis may also occur here. Connected with the tendon sheaths or, more commonly with the peri-articular structures of the wrist, small, firm, oval, or round swellings are often seen which are rendered more prominent by flexion of the wrist and are known as ganglia.

The extensor sheaths of the tendons of the back of the hand are practically prolongations of the walls of the different compartments of the posterior annular (*dorsal carpal*) ligament. They hold the same relations as the compartments, and enclose the same tendons which have been described as occupying the compartments of the posterior annular (*dorsal carpal*) ligament.

The muscles exposed are the extensors of the hand and fingers. They consist of three sets: the radial, the superficial, and the deep extensors.

Radial extensors (Plate CLXXIII).—Supinator longus (*brachio-radialis*), extensor carpi radialis longus, and extensor carpi radialis brevis.

The **supinator longus** (**brachio-radialis**) *arises* from the proximal two-thirds of the lateral condyloid (*epidcondylic*) ridge of the humerus, as high up as the musculo-spiral (*radial*) groove, and from the lateral intermuscular septum. It is a long fleshy muscle,the belly of which, with the other two muscles of this group, forms the prominence of the radial aspect of the forearm. Its flattened tendon is *inserted* into the base of the styloid process of the radius. It is wholly subcutaneous except at the distal part of its tendon, where it is crossed obliquely by the extensor ossis metacarpi pollicis (*abductor pollicis longus*) and extensor primi internodii pollicis (*extensor pollicis brevis*). It rests upon the musculo-spiral (*radial*) nerve, the radial recurrent artery, the radial vessels and nerve, the humerus, the supinator brevis (*supinator*) muscle, the extensores carpi radialis longus and brevis muscles, and the insertion of the pronator radii teres. On its medial side proximal to the elbow are the brachialis muscle, the musculo-spiral (*radial*) nerve, and the radial recurrent artery, and distal to the elbow, the tendon of the biceps brachii and the pronator radii teres.

Blood Supply.—From the radial and radial recurrent arteries.

Nerve Supply.—From a branch of the musculo-spiral (*radial*) nerve in the hollow of the elbow.

Action.—It slightly supinates the forearm, especially after full pronation, flexes the forearm, and in full supination is a slight pronator.

The **extensor carpi radialis longus** *arises* from the distal third of the lateral condyloid (*epicondylic*) ridge of the humerus, the lateral intermuscular septum, and the lateral condyle (*epicondyle*) of the humerus by the common extensor tendon; the fibers terminate at about the middle of the forearm in a flattened tendon, which passes laterally down the forearm to the wrist, and through a groove upon the back of the base of the radius just behind the styloid process, accompanied by the extensor carpi radialis brevis, to be *inserted* upon the radial side of the base of the metacarpal bone of the index finger. The muscle is overlapped on its radial anterior border by the supinator longus (*brachio-radialis*), and crossed at its distal end by the three extensors of the thumb. It lies upon the elbow-joint, the extensor carpi radialis brevis, and the dorsum of the wrist.

Blood Supply.—From the radial and radial recurrent arteries.

Nerve Supply.—From a branch of the musculo-spiral (*radial*) nerve in the hollow of the elbow.

Action.—It extends and abducts the wrist and flexes the elbow.

The **extensor carpi radialis brevis** *arises* from the lateral condyle (*epicondyle*) of the humerus, the adjacent intermuscular septum, the external lateral (*radial collateral*) ligament of the elbow-joint, and the deep fascia. In the middle of the forearm it ends in a flattened tendon which lies close to, and accompanies that of the extensor carpi radialis longus down the forearm. It passes through the groove upon the base of the radius and is *inserted* into the radial side of the base of the metacarpal bone of the middle finger. It occupies the same sheath as the tendon of the extensor carpi radialis longus and passes through the same compartment of the posterior annular (*dorsal carpal*) ligament. Proximally it is covered by the extensor carpi radialis longus, and distally by the extensors of the thumb. It rests upon the supinator brevis (*supinator*), the insertion of the pronator radii teres, the radius, and the carpus; upon its ulnar side it is in contact with the extensor digitorum communis.

Blood Supply.—From the radial and radial recurrent arteries.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It extends the wrist and is a subsidiary flexor of the elbow-joint.

Superficial Extensors.—(Plate CLXXIII.) The extensor digitorum communis, the extensor minimi digiti (*extensor digiti quinti proprius*), the extensor carpi ulnaris, and the anconeus.

The **extensor digitorum communis** *arises* by the common extensor tendon from the lateral condyle (*epicondyle*) of the humerus, the deep fascia, and adjacent intermuscular septa. Just below the middle of the forearm it divides into three tendons which together with the extensor indicis pass through a common compartment in the posterior annular (*dorsal carpal*) ligament, whence they diverge for *insertion* into the bases of the two distal phalanges of the four fingers. The muscle is subcutaneous, except where its tendons pass beneath the posterior annular (*dorsal carpal*) ligament, and lies upon the supinator brevis (*supinator*), extensors of the thumb and index finger, the posterior interosseous nerve and vessels, the carpus and the dorsal interossei muscles. On its ulnar side are the extensor digiti quinti and extensor carpi ulnaris.

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—Its chief function is to extend the phalanges; continuing its action it extends the wrist-joint and, to a slight extent, the elbow.

The **extensor minimi digiti** (**extensor digiti quinti proprius**) lies upon the ulnar side of the extensor digitorum communis muscle, with which it is usually connected. *Arising* from the lateral condyle (*epicondyle*) of the humerus by the common extensor tendon, from the deep fascia, and the adjacent intermuscular septa, it becomes tendinous in the distal part of the forearm, passes behind the radio-ulnar joint through a separate compartment of the posterior annular (*dorsal carpal*) ligament of the wrist, and then to the back of the little finger after uniting with the tendon of the extensor digitorum communis. It is covered above by the extensor digitorum communis and extensor carpi ulnaris, but below these it is superficial, except where it lies beneath the posterior annular (*dorsal carpal*) ligament. It rests upon the supintor brevis (*supinator*), the extensor ossis metacarpi pollicis (*abductor pollicis longus*), the extensor secundi internodii pollicis (*extensor pollicis longus*), and the extensor indicis (*extensor indicis proprius*).

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It extends the wrist-joint, the metacarpo-phalangeal, and the interphalangeal joints of the little finger.

The **extensor carpi ulnaris** *arises* by the common extensor tendon from the lateral condyle (*epicondyle*) of the humerus, from the middle third of the posterior border of the ulna in common with the flexor carpi ulnaris and flexor digitorum profundus and from the deep fascia. It lies superficially upon the ulnar side of the forearm, and ends in a tendon which goes through a groove back of the styloid process of the ulna and beneath the posterior annular (*dorsal carpal*) ligament, to be *inserted* into the base of the metacarpal bone of the little

finger. It is subcutaneous, except where it lies beneath the posterior annular (*dorsal carpal*) ligament, and rests upon the supinator brevis (*supinator*), the extensor ossis metacarpi pollicis (*abductor pollicis longus*), the extensor primi internodii pollicis (*extensor pollicis brevis*), the extensor secundi internodii pollicis (*extensor pollicis longus*), the extensor indicis proprius, the ulna, and the carpus. Its ulnar border is in relation with the anconeus and the posterior border of the ulna; its radial border with the extensor digiti quinti.

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It adducts and extends the wrist-joint and by its humeral attachment also aids in extending the elbow.

The **anconeus** is a small, triangular-shaped muscle, situated upon the radial side of the olecranon. It *arises* by a tendon from the back of the lateral condyle (*epicondyle*) of the humerus and the posterior ligament of the elbow-joint. From this origin its fibers diverge for *insertion* into the radial side of the olecranon and the triangular surface on the proximal fourth of the shaft of the ulna, and also into the fascia which covers it. It is superficial and lies against the elbow-joint, the orbicular (*annular*) ligament, the ulna, and a part of the supinator brevis (*supinator*). Its proximal edge is in contact with and parallel to the lowest fibers of the lateral head of the triceps; its distal radial margin adjoins the extensor carpi ulnaris.

Blood Supply.—From the interosseous recurrent artery.

Nerve Supply.—From the musculo-spiral (*radial*) nerve.

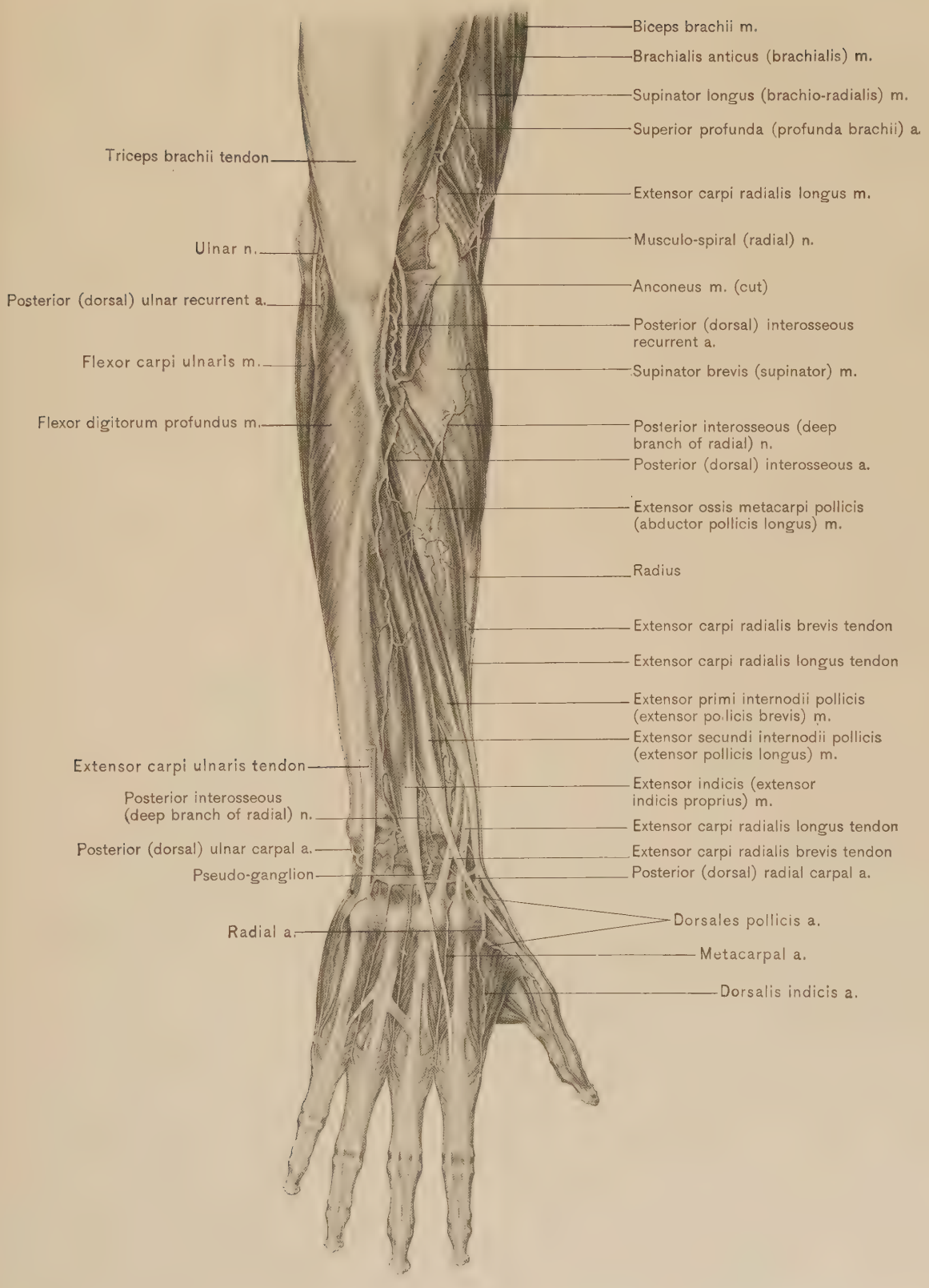
Action.—It extends the elbow-joint.

Dissection.—The extensor digitorum communis, extensor minimi digiti (*extensor digiti quinti proprius*), and extensor carpi ulnaris should now be severed in the middle of the forearm and reflected upward and downward, thus affording greater facility for the study of the following muscles:

Deep Extensors (Plate CLXXIV): supinator brevis (*supinator*), extensor ossis metacarpi pollicis (*abductor pollicis longus*), extensor primi internodii pollicis (*extensor pollicis brevis*), extensor secundi internodii pollicis (*extensor pollicis longus*), and extensor indicis (*extensor indicis proprius*).

The **supinator brevis** (**supinator**) is a broad, flat **muscle**, irregular in outline, and wrapped about the proximal end of the radius. It *arises* beneath the mass of extensor muscles from the distal posterior part of the lateral condyle (*epicondyle*) of the humerus, the external lateral (*radial collateral*) ligament of the elbow-joint where it blends with the orbicular (*annular*) ligament of the radius, the depression below the lesser sigmoid cavity (*radial notch*) of the ulna, and the fascia enveloping the muscle. Its proximal fibers, arranged in a loop, surround the neck of the radius, and are *inserted* into the posteromedial surface, while the

PLATE CLXXIV.


Biceps brachii m.
Brachialis anticus (brachialis) m.
Supinator longus (brachio-radialis) m.
Superior profunda (profunda brachii) a.
Triceps brachii tendon
Extensor carpi radialis longus m.
Musculo-spiral (radial) n.
Ulnar n.
Anconeus m. (cut)
Posterior (dorsal) ulnar recurrent a.
Posterior (dorsal) interosseous recurrent a.
Flexor carpi ulnaris m.
Supinator brevis (supinator) m.
Flexor digitorum profundus m.
Posterior interosseous (deep branch of radial) n.
Posterior (dorsal) interosseous a.
Extensor ossis metacarpi pollicis (abductor pollicis longus) m.
Radius
Extensor carpi radialis brevis tendon
Extensor carpi radialis longus tendon
Extensor primi internodii pollicis (extensor pollicis brevis) m.
Extensor secundi internodii pollicis (extensor pollicis longus) m.
Extensor carpi ulnaris tendon
Extensor indicis (extensor indicis proprius) m.
Posterior interosseous (deep branch of radial) n.
Extensor carpi radialis longus tendon
Posterior (dorsal) ulnar carpal a.
Extensor carpi radialis brevis tendon
Pseudo-ganglion
Posterior (dorsal) radial carpal a.
Dorsales pollicis a.
Radial a.
Metacarpal a.
Dorsalis indicis a.

DEEP MUSCLES OF BACK OF FOREARM, POSTERIOR (DORSAL) INTEROSSEOUS ARTERY AND NERVE.

remainder of the muscle is attached to the anterolateral surface of the radius, from the oblique line, and the bicipital (*radial*) tuberosity to the insertion of the pronator radii teres. It is covered anterolaterally by the biceps, the pronator radii teres, the supinator longus (*brachio-radialis*), extensores carpi radialis longus and brevis, and the radial vessels and nerve; posteriorly, by the anconeus, the extensor digitorum communis, extensor minimi digiti (*extensor digiti quinti proprius*), and extensor carpi ulnaris muscles, and the interosseous recurrent artery. It rests upon the elbow-joint, the proximal radio-ulnar joint and the radius.

Blood Supply.—From the radial and interosseous recurrent arteries.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve, by which it is pierced.

Action.—It is the most powerful supinator of the forearm, being assisted by the biceps. It also helps to keep the head of the radius in position.

The **extensor ossis metacarpi pollicis** (**abductor pollicis longus**), situated immediately below the supinator brevis (*supinator*), *arises* from the back of the shaft of the radius and ulna from a surface about five centimeters (two inches) in length just distal to the inferior margins of the supinator brevis (*supinator*) and anconeus muscles and the intervening interosseous membrane. Its tendon passes distally and laterally in an oblique direction crossing over the radial carpal extensor muscles, and going through a groove upon the radius, lateral to the styloid process. At about seven and half centimeters (three inches) proximal to the wrist it passes under the posterior annular (*dorsal carpal*) ligament and is *inserted*, in common with that of the extensor primi internodii pollicis (*extensor pollicis brevis*), into the radial side of the base of the metacarpal bone of the thumb, frequently also sending a slip to the trapezium (*multangulum majus*). It is covered by the extensores digitorum communis, carpi ulnaris, and digiti minimi (*extensor digiti quinti proprius*) and the posterior annular (*dorsal carpal*) ligament, and is crossed by the posterior (*dorsal*) interosseous nerve and vessels. It lies upon the ulna, the interosseous membrane, the radius, the extensor primi internodii pollicis (*extensor pollicis brevis*), and extensor secundi internodii pollicis (*extensor pollicis longus*), the tendons of the extensores carpi radialis longus and brevis, the radial vessels, and the wrist-joint. Above it are the supinator brevis (*supinator*) and anconeus, and below it the extensor primi internodii pollicis (*extensor pollicis brevis*) and extensor secundi internodii pollicis (*extensor pollicis longus*).

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It abducts and extends the metacarpal bone of the thumb, abducts the wrist-joint, and supinates the forearm.

The **extensor primi internodii pollicis** (**extensor pollicis brevis**), the smallest extensor of the thumb, *arises* from the back of the shaft of the radius and the interosseous membrane just below the extensor ossis metacarpi pollicis (*abductor pollicis longus*), and runs parallel with that muscle and lateral to the styloid process of the radius. It passes through the posterior annular (*dorsal carpal*) ligament and through the same groove as the extensor ossis metacarpi pollicis (*abductor pollicis longus*), to be *inserted* into the base of the proximal phalanx of the thumb. It lies upon the radius and interosseous membrane, the tendons of the extensores carpi radialis longus and brevis, the radial vessels, the wrist-joint, the metacarpal bone, and metacarpo-phalangeal joint of the thumb. It is covered by the extensores ossis metacarpi pollicis (*abductor pollicis longus*), digitorum communis, minimi digiti (*extensor digiti quinti proprius*), and the posterior annular (*dorsal carpal*) ligament. This muscle is peculiar to the human hand.

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It extends the first joint of the thumb, abducts and extends the metacarpal bone of the thumb, and abducts the hand.

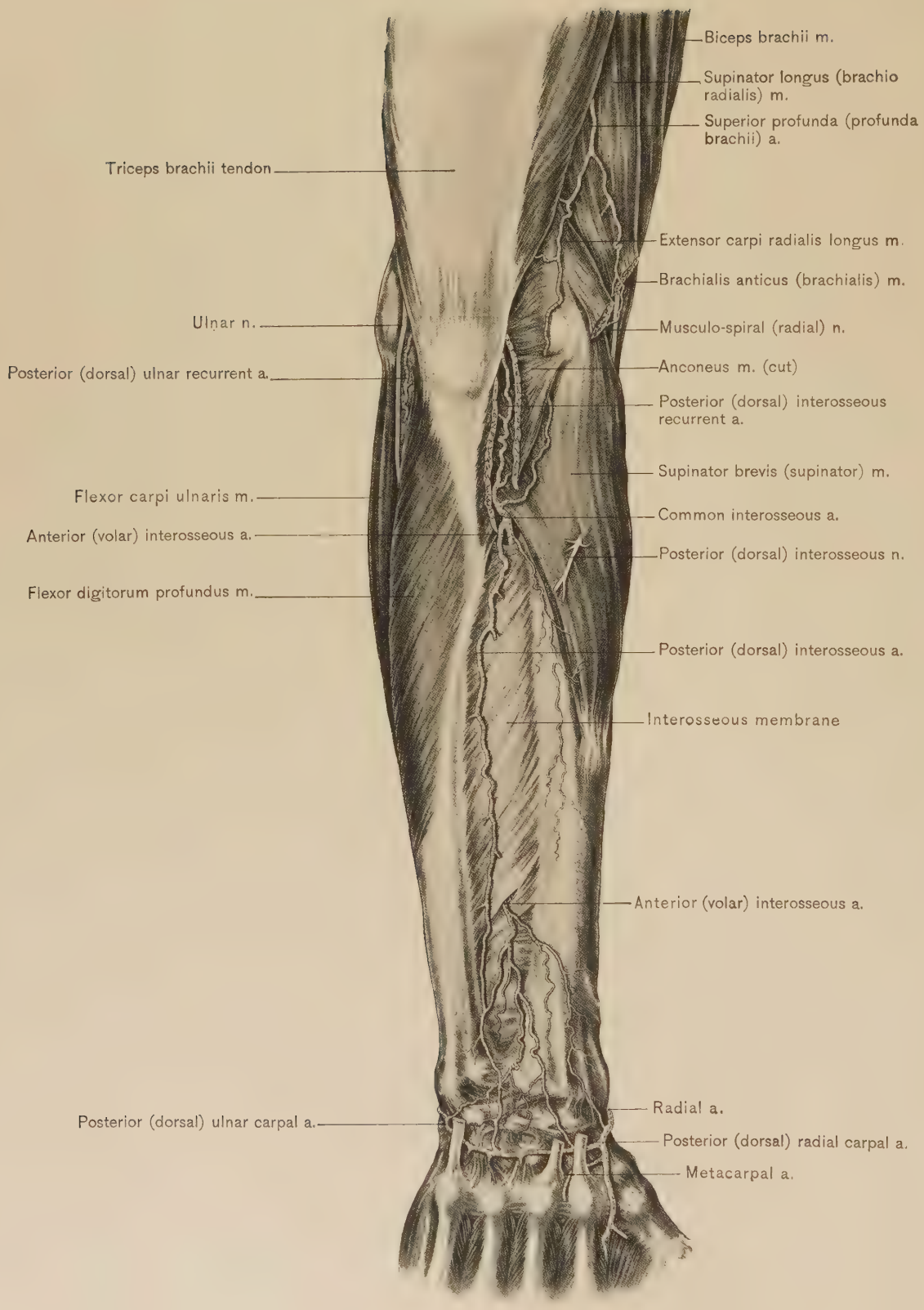
The **extensor secundi internodii pollicis** (**extensor pollicis longus**), larger than the preceding muscle, *arises* from the back of the shaft of the ulna and the interosseous membrane, below the attachment of the extensor ossis metacarpi pollicis (*extensor pollicis brevis*), and ends in a tendon which, passing independently through the posterior annular (*dorsal carpal*) ligament and through a separate groove upon the back of the radius, extends obliquely across the wrist and the tendons of the extensores carpi radialis longus and brevis, for insertion into the back of the base of the distal phalanx of the thumb. At the wrist, in the triangular interval (anatomic snuff-box) between the extensor secundi internodii pollicis (*extensor pollicis longus*) and the other two thumb extensor tendons, the radial artery will be found. The muscle and the tendon are covered by the extensores ossis metacarpi pollicis (*abductor pollicis longus*), digitorum communis, minimi digiti (*extensor digiti quinti proprius*), and carpi ulnaris, the posterior (*dorsal*) interosseous artery and the posterior annular (*dorsal carpal*) ligament. It rests upon the interosseous membrane, the tendons of the extensores carpi radialis longus and brevis, the radius, the wrist-joint, the radial vessels, the metacarpal bone of the thumb and its proximal phalanx.

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It extends the thumb-joints, adducts the metacarpal bone of the thumb, abducts the hand, and supinates the forearm.

PLATE CLXXV.



ANTERIOR (VOLAR) INTEROSSEOUS AND POSTERIOR (DORSAL) INTEROSSEOUS ARTERIES.

The **extensor indicis** (**extensor indicis proprius**) is a narrow, elongated muscle *arising* from the back of the ulna and the interosseous membrane distal to the attachment of the extensor secundi internodii pollicis (*extensor pollicis longus*) muscle; with the lateral tendon of the extensor digitorum communis, it passes through the compartment beneath the posterior annular (*dorsal carpal*) ligament, to be *inserted* into the medial side of that tendon. It is covered by the extensores digitorum communis, minimi digiti (*extensor digiti quinti proprius*), secundi internodii pollicis (*extensor pollicis longus*), and the posterior annular (*dorsal carpal*) ligament. It lies upon the interosseous membrane, the wrist, and the dorsal interosseous muscle of the second interosseous space. This muscle may be absent, or its tendon may send slips to the third and fourth fingers.

Blood Supply.—From the posterior (*dorsal*) interosseous artery.

Nerve Supply.—From the posterior (*dorsal*) interosseous nerve.

Action.—It extends the wrist-joint, the metacarpo-phalangeal, and the interphalangeal joints of the index-finger.

The **posterior interosseous** (**dorsal interosseous**) **artery** (Plate CLXXV), a branch of the common interosseous branch of the ulnar, passes backward between the bones of the forearm and between the upper border of the interosseous membrane and the oblique ligament (*chorda obliqua*). It emerges behind, between the supinator brevis (*supinator*) proximally and the extensor ossis metacarpi pollicis (*abductor pollicis longus*) distally, where it gives off a large ascending branch, the *interosseous recurrent*. It also gives off *muscular* and *articular branches*. Continuing downward over the ulnar origin of the extensores ossis metacarpi pollicis (*abductor pollicis longus*), primi internodii pollicis (*extensor pollicis brevis*), secundi internodii pollicis (*extensor pollicis longus*), and the extensor indicis proprius, it anastomoses with the termination of the anterior (*volar*) interosseous, after that artery has passed through the interosseous membrane, and then with the posterior carpal branches of the radial and ulnar arteries. The *interosseous recurrent artery* ascends between the supinator brevis (*supinator*) and anconeus muscles to the sulcus between the lateral condyle (*epicondyle*) and olecranon process; it anastomoses with the superior profunda (*profunda brachii*), anastomotica magna (*inferior ulnar collateral*), radial recurrent, and posterior ulnar recurrent arteries. The *muscular branches* of the posterior (*dorsal*) interosseous artery supply the muscles between which it lies; the *articular branches* supply the wrist-joint.

The *terminal portion of the* **anterior interosseus** (**volar interosseous**) **artery** is seen lying on the posterior surface of the lower part of the interosseous membrane, having pierced the interosseous membrane at the proximal border of the pronator quadratus, where it is joined by a branch of the posterior (*dorsal*) inter-

osseous artery to help form the posterior carpal rete. It runs distally over the wrist, beneath the extensor tendons, and anastomoses with the posterior (*dorsal*) carpal arch.

The **posterior interosseous** (**dorsal interosseous**) **nerve**, a continuation of the deep terminal branch of the musculo-spiral (*radial*), winds around the lateral side of the proximal end of the radius, passes through the substance of the supinator brevis (*supinator*) muscle to the back of the forearm, and then, in company with the posterior (*dorsal*) interosseous artery, extends distally between the superficial and the deep extensor muscles, to the upper border of the extensor secundi internodii pollicis (*extensor pollicis longus*). In the forearm it supplies *muscular branches* to the extensor carpi radialis brevis, supinator brevis (*supinator*), extensores digitorum communis, minimi digiti (*extensor digiti quinti proprius*), carpi ulnaris, ossis metacarpi pollicis (*abductor pollicis longus*), primi internodii pollicis (*extensor pollicis brevis*) and secundi internodii pollicis (*extensor pollicis longus*), and the extensor indicis (*extensor indicis proprius*), and *cutaneous* branches to the skin on the back of the forearm and the wrist. At the upper border of the extensor secundi internodii pollicis (*extensor pollicis longus*), the posterior (*dorsal*) interosseous nerve leaves the posterior (*dorsal*) interosseous artery and runs beneath the extensor secundi internodii pollicis (*extensor pollicis longus*) and the extensor indicis (*extensor indicis proprius*), upon the interosseous membrane, and accompanies the terminal part of the anterior (*volar*) interosseous artery to the back of the wrist. Here it ends in a gangliform enlargement which gives off *articular filaments* to the wrist and intercarpal joints.

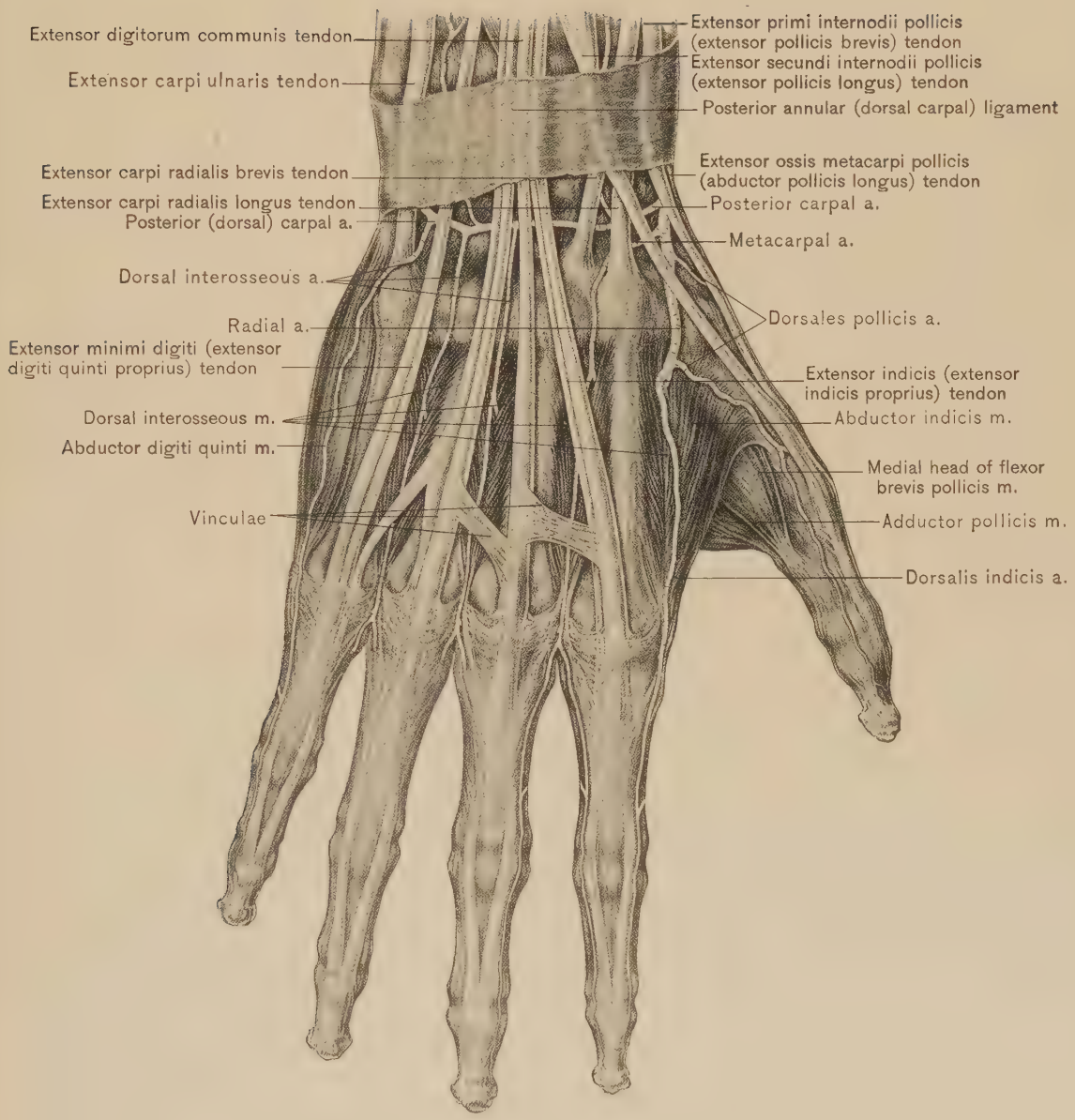
A blow upon the front of the lateral condyle (*epicondyle*) or lateral side of the proximal fifth of the radius may so contuse the posterior (*dorsal*) interosseous nerve as to cause paralysis of the supinator brevis (*supinator*) and the extensors of the wrist and fingers, except the radial extensors which are supplied by branches of the musculo-spiral (*radial*) before it bifurcates.

THE BACK OF THE HAND

The superficial veins, nerves, and deep fascia of the back of the hand having been described with the posterior surface of the forearm, it remains to reflect the deep fascia from above downward in order to expose the extensor tendons and the remaining deep structures of the back of the hand (Plate CLXXVI).

The **extensor tendons** emerge from beneath the posterior annular (*dorsal carpal*) ligament and diverge for insertion into the dorsal aspect of their respective digits. Those of the extensor digitorum communis become narrow and thickened opposite the metacarpo-phalangeal joints, at which point they give

PLATE CLXXVI.


Extensor digitorum communis tendon
Extensor carpi ulnaris tendon
Extensor carpi radialis brevis tendon
Extensor carpi radialis longus tendon
Posterior (dorsal) carpal a.
Dorsal interosseous a.
Radial a.
Extensor minimi digiti (extensor digiti quinti proprius) tendon
Dorsal interosseous m.
Abductor digiti quinti m.
Vinculae
Extensor primi internodii pollicis (extensor pollicis brevis) tendon
Extensor secundi internodii pollicis (extensor pollicis longus) tendon
Posterior annular (dorsal carpal) ligament
Extensor ossis metacarpi pollicis (abductor pollicis longus) tendon
Posterior carpal a.
Metacarpal a.
Dorsales pollicis a.
Extensor indicis (extensor indicis proprius) tendon
Abductor indicis m.
Medial head of flexor brevis pollicis m.
Adductor pollicis m.
Dorsalis indicis a.

TENDONS AND ARTERIES OF BACK OF HAND.

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off fasciculi which are attached to the lateral ligaments of these articulations. They then form a broad aponeurosis which covers the entire back of the proximal phalanges, where they are joined by the tendons of the interossei and lumbricales muscles. Opposite the proximal interphalangeal joint each tendon divides into a central slip which is *inserted* into the base of the second phalanx, and two collateral slips which unite over the middle phalanx, for insertion into the dorsal aspect of the base of the terminal phalanx. These tendons constitute the posterior ligaments of the metacarpo-phalangeal and interphalangeal joints. On the proximal side of the metacarpo-phalangeal articulations the tendon of the ring finger sends off two lateral divergent slips, which are attached to the adjacent tendons of the little and middle fingers. This is important because it restricts the independent extension of the ring finger, a defect especially troublesome to pianists and violinists, who, on account of this interference with the required movement, sometimes have these restricting bands divided. The tendon of the middle finger is also connected to the extensor communis tendon of the index finger by a band of transverse fibers. The tendon of the extensor indicis (*extensor indicis proprius*) joins that of the common extensor over the proximal phalanx of the index finger. The tendon of the extensor minimi digiti (*extensor digiti quinti proprius*) divides into two parts, one of which joins the common extensor tendon of the little finger, the other ending in the dorsal expansion common to this tendon and that of the tendon of the extensor digitorum communis.

Dissection.—Remove the fascia overlying the dorsal interossei muscles and the vessels of the dorsum of the wrist and hand. The vessels are the radial artery and its branches, the posterior (*dorsal*) carpal branch of the ulnar artery, and the terminal portion of the anterior (*volar*) interosseous artery.

The **radial artery,** as it leaves the front of the forearm, lies first upon the external lateral (*radial collateral*) ligament of the wrist, then upon the scaphoid (*navicular*), the trapezium (*multangulum majus*), and the base of the metacarpal bone of the thumb, and under the tendons of the extensores ossis metacarpi pollicis (*abductor pollicis longus*), primi internodii pollicis (*extensor pollicis brevis*), and secundi internodii pollicis (*extensor pollicis longus*), whence it continues to the apex of the interval situated between the metacarpal bones of the thumb and the index finger, where it passes between the two heads of the first dorsal interosseous muscle into the palm, to form the deep palmar (*deep volar*) arch. On the dorsal aspect of the wrist it gives off the *posterior carpal* (*dorsal carpal*), *the first dorsal interosseous* (*dorsal metacarpal*), the *dorsalis pollicis*, and the *dorsalis indicis arteries.*

The **posterior carpal** (**dorsal carpal**) **artery** arises on the radial side of the wrist and passes across the carpal bones beneath the extensor tendons. It joins

a corresponding branch from the ulnar artery, and beneath the tendons forms the *posterior (dorsal) carpal arch*, or network. From this arch arise the *second* and *third interosseous (dorsal metacarpal) arteries*, which pass downward over the third and fourth interosseous intervals, and divide into dorsal digital branches which supply the contiguous sides of the middle, ring, and little fingers. At the carpal ends of the interosseous spaces they are joined by the perforating branches of the deep palmar (*deep volar*) arch. At the distal ends of the interosseous spaces they give off *anterior (deep distal) perforating* branches which join the digital arteries of the corresponding intervals. The posterior carpal arch is joined by the terminal portion of the anterior (*volar*) interosseous artery. The *posterior (dorsal) carpal branch of the ulnar artery* arises from the latter vessel a short distance proximal to the pisiform bone, and winds around the ulna beneath the flexor carpi ulnaris to the back of the wrist, where it lies beneath the extensor tendons and anastomoses with the posterior (*dorsal*) carpal branch of the radial artery to form the posterior (*dorsal*) carpal arch, described above. The terminal portion of the anterior (*volar*) interosseous artery has been described with the back of the forearm.

The **first dorsal interosseous (first dorsal metacarpal) artery** generally arises from the radial, although, at times, it comes from the posterior (*dorsal*) carpal arch. It passes downward over the second interosseous space and divides into dorsal digital branches which supply the adjacent sides of the index and middle fingers. Like the second and third interosseous (*dorsal metacarpal*) arteries, it is joined by a perforating branch from the deep palmar (*deep volar*) arch, and gives off an *anterior perforating branch* to join the corresponding digital artery.

The **dorsal digital arteries** terminate at the proximal interphalangeal joints, where they anastomose with the posterior branches of the collateral digital arteries.

The **dorsalis pollicis** is a small, slender artery arising from the radial near the base of the first metacarpal bone; passing distally, it divides to supply each side of the thumb.

The **dorsalis indicis artery** arises from the radial immediately before it passes into the palm, and runs over the abductor indicis muscle, on the radial side of the metacarpal bone and proximal phalanx of the index finger, to anastomose opposite the proximal interphalangeal joint with a posterior branch of the radialis indicis (*volaris indicis radialis*) artery.

The **dorsal interossei** are four bipenniform **muscles** each of which *arises* by two heads from the adjacent sides of the proximal one-half or two-thirds of the shafts of the metacarpal bones, but the origin is more extensive from the metacarpal bones of the fingers into which they are inserted. They are numbered

in order from the radial side. The *first* and largest dorsal interosseous, or abductor indicis, and the *second* are *inserted* into the radial side of the base of the proximal phalanx and the extensor tendon of the index and middle fingers, respectively; the *third* and the *fourth* into the ulnar side of the base of the proximal phalanx and the extensor tendon of the middle and ring fingers, respectively. The intervals between the bases of the metacarpal bones and the converging fibers of the proximal ends of the muscles permit the passage of the perforating branches from the deep palmar (*volar*) arch; while the interval between the origins of the first dorsal interosseous muscle gives passage to the radial artery.

Blood Supply.—From the deep palmar and posterior (*dorsal*) carpal arches.

Nerve Supply.—From the deep branch of the ulnar nerve.

Action.—They abduct the fingers, flex the metacarpo-phalangeal joints, and extend the two distal phalanges. The action of the first dorsal interosseous (abductor indicis) is clearly demonstrated by abducting the index finger, flexing its metacarpo-phalangeal joint, and keeping the two distal phalanges extended, thus contracting the muscle, which can be plainly felt and seen on the dorsum of the hand in the first interosseous space.

JOINTS

A **joint** consists of the adjacent portions of two or more bones, articular cartilage, ligaments, and one or two synovial membranes.

The **articular ends of the bones** are composed chiefly of cancellous tissue, which gives strength, elasticity, a large surface for articulation, and a minimum of weight. At its articular surface the cancellous tissue is covered by a thin crust of dense, compact bone which contains no Haversian canals. The articular ends of the long bones being supplied by the articular arteries, have a blood supply independent of that furnished to the shaft by the nutrient artery. This portion of the bone is occasionally affected by inflammation, which is frequently tuberculous in character. The epiphysis is especially apt to be involved in acute inflammation of the bones in children, and care should be taken not to diagnose the condition as an arthritis. Since the thin crust of compact bone upon the articular surface offers but slight obstruction to the inflammatory process, failure to remove the diseased tissue and to drain the affected parts may lead to involvement of the articular cartilage and the joint.

The **articular cartilage** covers the smooth articular ends of the bones. It is of the hyaline variety, and contains no blood-vessels. Its nourishment is supplied

through lymph channels which pass between the cartilage cells, the lymph being derived from the vessels in the ends of the bones and in the synovial membrane of the joint; therefore, if the cartilage is partially detached from the bone by external violence, the detached area loses more or less of its nourishment, and necrosis may result. In deforming arthritis this cartilage disappears and the articular surfaces of the bones become hard and eburnated, with absorption, or hypertrophy, or both as the result.

All true joints contain a **synovial membrane** (**stratum synoviale**) which lines the capsule of the joint and at the margin of the articular cartilage becomes continuous with the surface of the cartilage. Some joints, like the temporo-maxillary (*mandibular*), which are subdivided by an interarticular cartilage, contain two synovial sacs. The synovial membranes, like the serous membranes, are composed of flat endothelial cells which secrete the synovial fluid which lubricates the joints. Inflammation of a joint begins in this membrane more frequently than in other parts of the joint, and because of the close relation between the membrane and the ligaments, the latter also are likely to be involved. In tuberculous arthritis the softening of the ligaments permits increased lateral motion of the joint, whereas in deforming arthritis the infiltration and contraction of the ligaments and bands of adhesions cause stiffness and false ankylosis of the joint.

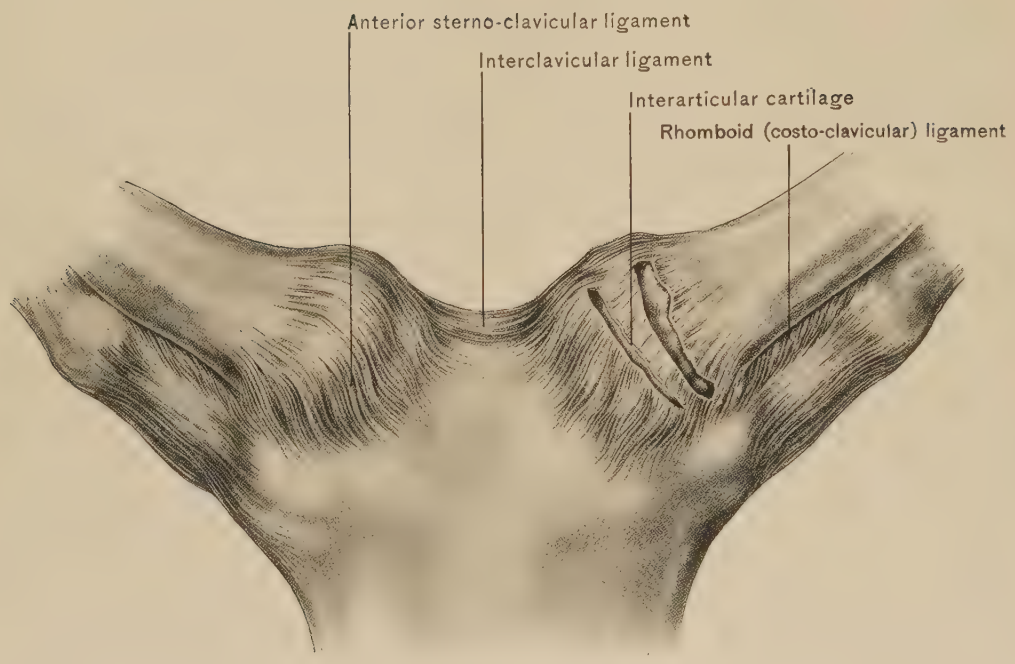
For practical purposes all true joints may be divided into three classes: those which derive their strength chiefly from the conformation of the bones, those whose strength depends upon their ligaments, and those which largely depend upon surrounding muscles for support. The hip-joint is the best example of the first class. External violence applied to such a joint is more likely to produce a contusion than a sprain or dislocation. In joints of the second class, such as the radio-ulnar, a sprain is more common than a contusion or a dislocation, while in joints of the third class, the best example of which is the shoulder, dislocation is more common than contusion or sprain.

In the diagnosis of fractures, dislocations, and disease of the joints of the extremities it is imperative to compare the affected with the non-affected member.

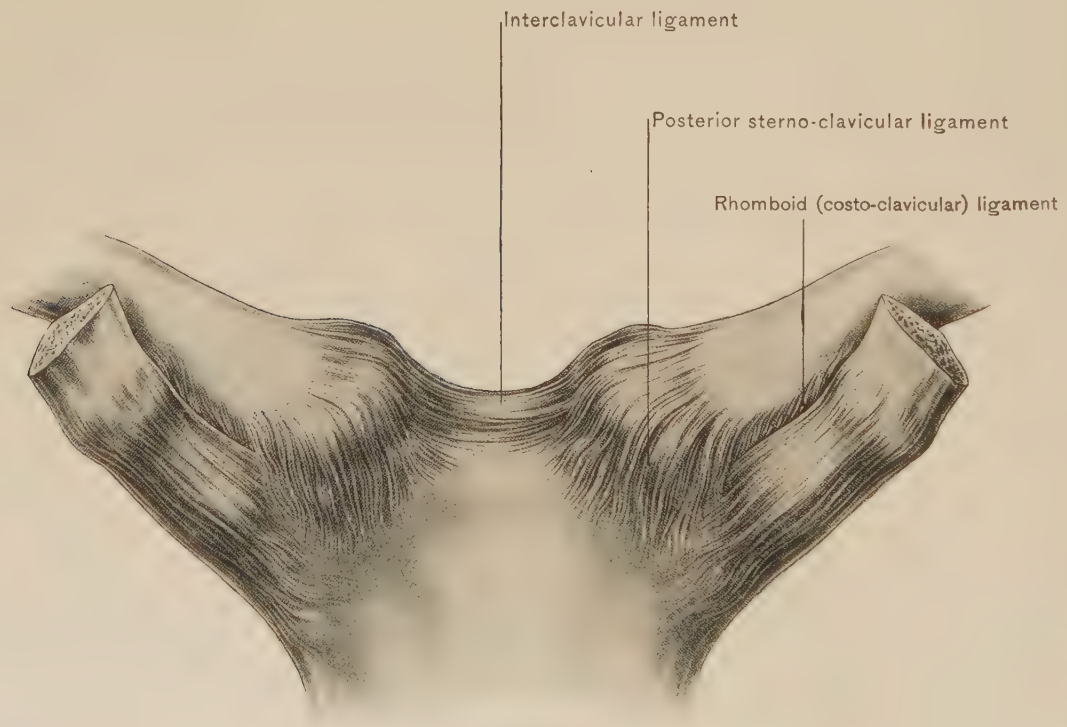
JOINTS OF THE UPPER EXTREMITY

The joints of the upper extremity include the sterno-clavicular, the acromio-clavicular, the shoulder, or scapulo-humeral, the elbow, the superior (*proximal*) and inferior (*distal*) radio-ulnar, the radio-carpal, or wrist, the intercarpal, or medio-carpal, the carpo-metacarpal, the metacarpo-phalangeal, and the inter-phalangeal.

PLATE CLXXVII.



STERNO-CLAVICULAR JOINT—ANTERIOR VIEW.



STERNO-CLAVICULAR JOINT—POSTERIOR VIEW.

THE STERNO-CLAVICULAR JOINT

The **sterno-clavicular** (Plate CLXXVII), an arthrodial joint, is formed by the superolateral part of the manubrium sterni and the medial end of the clavicle, which is larger than the bed, or articulating surface, of the manubrium in which it rests. Both surfaces are covered with cartilage and are separated by the interarticular fibrocartilage (*articular disc*). The line of the joint slopes downward and lateralward. The first costal cartilage gives attachment to one of the ligaments of the joint. These parts are bound together by five ligaments: the anterior and the posterior sterno-clavicular, the interclavicular, the costo-clavicular, or rhomboid, and the interarticular fibrocartilage.

The **anterior sterno-clavicular ligament,** which covers the front of the joint, is a fibrous membrane extending from the supero-anterior surface of the medial end of the clavicle to the supero-anterior surface of the manubrium sterni. It is covered by the skin and fasciæ and the sternal origin of the sterno-mastoid; it is in relation posteriorly with the interarticular fibrocartilage (*articular disc*) and the two synovial sacs.

The **posterior sterno-clavicular ligament** is attached to the posterior surface of the medial end of the clavicle and to the manubrium sterni, very much like the attachments of the anterior ligament. Anterior to the ligament are the interarticular fibrocartilage (*articular disc*) and the two synovial sacs, posterior to it are the sterno-hyoid and sterno-thyroid muscles.

The **interclavicular ligament** is a strong, rounded, fibrous band which varies considerably in size, and extends from the superior surface of the sternal end of one clavicle to the same part of the other. It is attached to the superior surface of the manubrium sterni between the ends of the clavicles, and is covered in front by the skin and fasciæ, while behind it is in relation with the sterno-thyroid muscles.

The **costo-clavicular, or rhomboid, ligament,** is a short, flat, quadrangular, powerful ligament attached below to the superior surface of the sternal end of the cartilage of the first rib, and above to the rhomboid depression on the under surface of the sternal end of the clavicle. This ligament limits displacement in cases of luxation. It lies behind the tendinous origin of the subclavius muscle and in front of the subclavian vein.

Dissection.—In order to expose the interarticular fibrocartilage (*articular disc*) sever the costo-clavicular and the anterior sterno-clavicular ligaments.

The **interarticular fibrocartilage** (**articular disc**), a flat disc, corresponding closely in size and outline to the sternal end of the clavicle, is situated between the sternal end of the clavicle and the clavicular notch of the sternum, where it

acts as a buffer and prevents the clavicle from being pushed medialward over the sternum. Below, it is attached to the first chondro-sternal junction, and above, to the upper and posterior part of the sternal end of the clavicle, where it blends with the interclavicular ligament and the anterior and posterior ligaments. It is thinnest in the center, and thickest superiorly, medially, and posteriorly. This fibrocartilaginous disc divides the sterno-clavicular joint into two compartments, each of which has a separate synovial sac, the medial one being the larger of the two. These sacs sometimes communicate by means of an opening in the cartilage.

Blood Supply.—From the internal mammary, superior thoracic (*thoraco-suprema*), and suprascapular (*transverse scapular*) arteries.

Nerve Supply.—From the branch of the brachial plexus which supplies the subclavius muscle.

Movements.—This joint is the center of *motion* for the shoulder, and admits of circumduction and of limited movement upward, downward, forward, and backward. Dislocation of the clavicle at this articulation does not often occur, because the combined strength of the ligaments compensates for the lack of adaptation of the articular surfaces of the bones. The adjacent muscles assist in preventing luxation. If luxation does occur it is of the anterior variety.

THE ACROMIO-CLAVICULAR JOINT

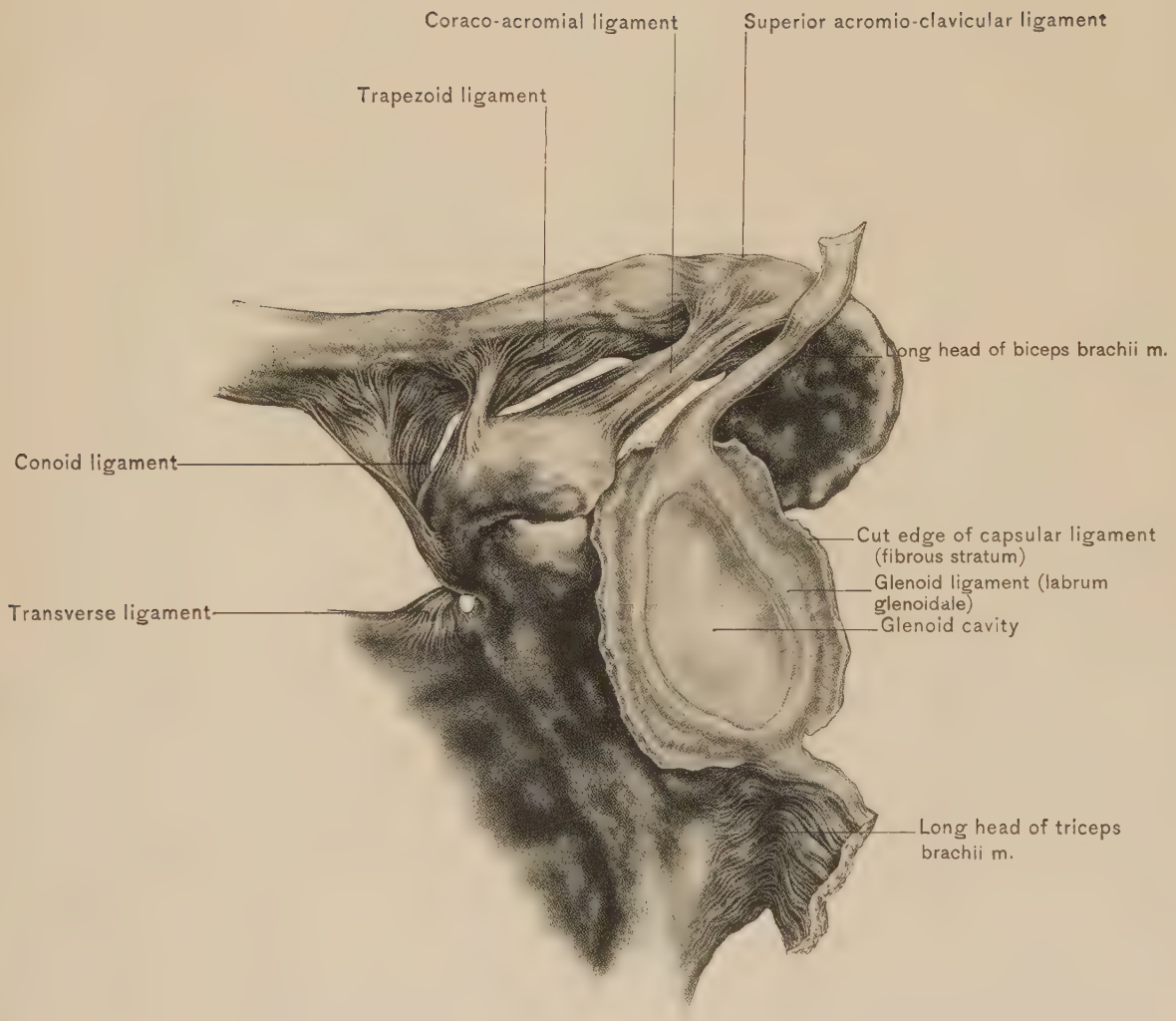
The **acromio-clavicular** (Plates CLXXVIII; CLXXIX), an arthrodial joint, is formed by the acromial end of the clavicle and the acromion process of the scapula. The surface of the joint looks downward and inward, thus favoring luxation of the clavicle upward. The bones are held in place by the ligaments proper, which are the superior acromio-clavicular, the inferior acromio-clavicular, the interarticular fibrocartilage (*articular disc*), and the coraco-clavicular, an accessory ligament.

The **superior acromio-clavicular ligament** covers the upper surface of the joint and is attached to the contiguous margins of the two bones. It is quadrilateral in shape, and is composed of parallel transverse fibers which interlace with the tendinous fibers of the trapezius and deltoid muscles. It is covered by skin and fasciæ.

The **inferior acromio-clavicular ligament,** the counterpart of the preceding, covers the under surface of the joint, and is similarly attached. Below, it is in relation with the tendon of the supraspinatus muscle. These two ligaments are continuous around the joint and constitute its capsule.

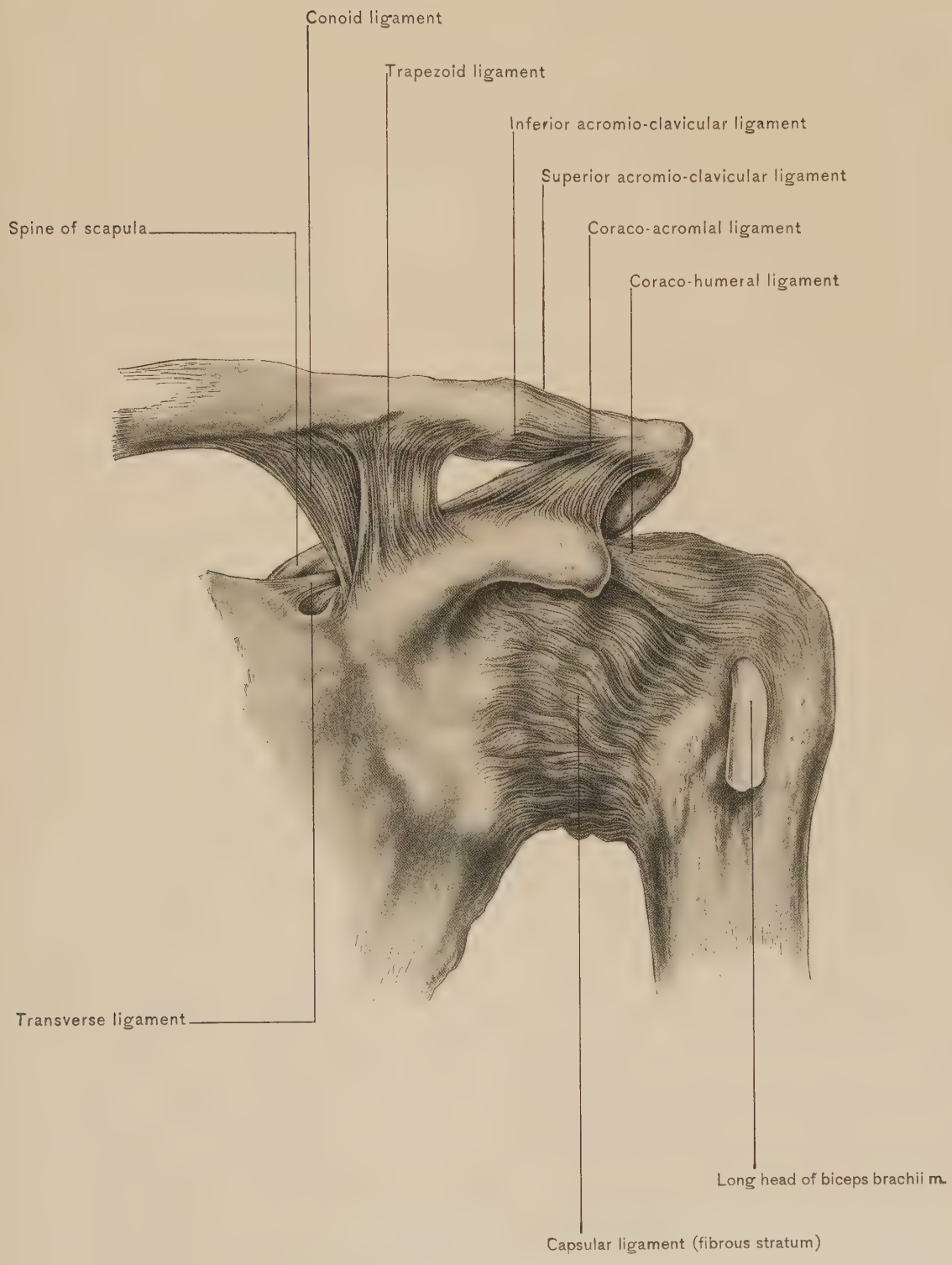
An **interarticular fibrocartilage** (**articular disc**) is sometimes found in this joint and can be exposed by dividing the superior acromio-clavicular ligament.

PLATE CLXXVIII.



SCAPULO-CLAVICULAR AND ACROMIO-CLAVICULAR JOINTS AND GLENOID LIGAMENT (LABRUM GLENOIDALE).

PLATE CLXXIX.



SCAPULO-CLAVICULAR, ACROMIO-CLAVICULAR, AND SCAPULO-HUMERAL JOINTS—ANTERIOR VIEW.

When present, it is rarely a complete disc, and occupies the upper part of the joint. There is but one synovial membrane.

The **coraco-clavicular ligament,** composed of two parts, trapezoid and conoid, connects the clavicle and the coracoid process of the scapula. The *trapezoid ligament*, the anterior of the two, is quadrilateral in shape, and is attached to the upper surface of the coracoid process and to the oblique ridge on the under surface of the clavicle. Posteriorly, it is continuous with the conoid ligament, while anteriorly and laterally, it has a free margin. The *conoid ligament*, triangular in shape, with its base above, is attached by its apex to a rough impression upon the base of the coracoid process on the medial side of the trapezoid ligament; by its base it is attached to the conoid tubercle, and for about one centimeter to a ridge on the under surface of the clavicle. In front and laterally, the conoid ligament is continuous with the trapezoid. Between the two there is often a bursa. It is in relation with the subclavius and deltoid muscles in front, and with areolar tissue, fat, and the insertion of the trapezius behind.

Movements.—Slight gliding, rotatory, or forward and backward movement, limited by the two portions of the coraco-clavicular ligament. The trapezoid and conoid ligaments limit the movements of the scapula at the acromio-clavicular joint and (especially the trapezoid) prevent the acromion from being carried medially below the acromial end of the clavicle, in case of a blow on the side of the shoulder.

Upward dislocation of the acromial end of the clavicle is not uncommon; it is characterized by an undue prominence of the acromial end of the bone.

Blood Supply.—From the suprascapular (*transverse scapular*), acromio-thoracic (*thoraco-acromial*), and posterior circumflex arteries.

Nerve Supply.—From the suprascapular and circumflex (*axillary*) nerves.

The **ligaments proper** of the scapula are the coraco-acromial and the transverse (*superior transverse scapular*) ligaments.

The **coraco-acromial ligament,** oblong in shape, is attached by its base to the entire lateroposterior border of the coracoid process; by its apex to the tip of the acromion process. It completes the coraco-acromial arch, which is above the head of the humerus. It is covered by the clavicle and the deltoid muscle and is separated from the capsular ligament of the shoulder-joint by a bursa.

The **superior transverse scapular, or suprascapular, ligament,** a distinct short, flat band, bridges over the suprascapular notch, converting it into a foramen which gives passage to the suprascapular nerve and vein (*transverse scapular vein*); the suprascapular (*transverse scapular*) artery passes over it.

The **inferior transverse scapular ligament** is thin and round. It extends from the root of the acromion to the posterior margin of the glenoid cavity over

the wall of the scapula. The suprascapular (*transverse scapular*) artery runs through the space thus formed.

In **dislocation of the scapula** the inferior angle of the bone slips from under the upper portion of the latissimus dorsi muscle, resulting in a condition known as "winged scapula." It is due to general weakness of the muscles, as in pulmonary tuberculosis and paralysis of the serratus magnus (*serratus anterior*) muscle, this muscle keeping the scapula applied to the chest wall with the aid of the latissimus dorsi. Consequently, any condition which weakens these muscles allows this angle to project.

THE SHOULDER-JOINT (Plate CLXXIX)

The **shoulder,** an enarthrodial, or ball-and-socket, joint, is formed by the glenoid cavity of the scapula and the head of the humerus, which are united by the capsular and coraco-humeral ligaments. The joint is intended to permit motion, and not to support weight or to resist force. The glenoid cavity, which is deepened by the glenoid ligament (*labrum glenoidale*) attached to its margin, being much smaller than the head of the humerus allows greater freedom of motion.

The **capsular ligament** (**fibrous stratum**) is attached to the margin of the glenoid cavity of the scapula, the lateral side of the fibrocartilaginous margin and to the anatomical neck of the humerus and bridges over the proximal end of the bicipital (*intertubercular*) sulcus. The capsule is very loose, or sacciform, to permit free movement. The capsular ligament is perforated at two points: above, where the bursa beneath the tendon of the subscapularis communicates with the shoulder-joint, and laterally, where the long tendon of the biceps pierces it between the tuberosities of the humerus. Sometimes there is a synovial extension beneath the suraspinatus tendon and occasionally a communication with the subacromial bursa. Pus within the joint would tend to find an exit through one of the above openings. The three *gleno-humeral bands*, or ligaments, are merely thickened portions of the capsule on its anteromedial aspect, appearing as flattened bands extending from the anterior border of the glenoid cavity to the anterior aspect of the humerus. The superior gleno-humeral ligament is said to be homologous with the ligamentum teres in the hip. The insertions of the subscapularis, the teres minor, infraspinatus, and supraspinatus muscles strengthen the joint.

The **coraco-humeral, or accessory, ligament** is a thickening of that part of the capsule which extends from the lateral border of the coracoid process, below the coraco-acromial ligament, to the greater tuberosity of the humerus,

some of the fibers being raised from the capsule and thus becoming dignified into a separate ligament. It is supposed by some to be a regression of the tendon of the pectoralis minor muscle.

The **glenoid ligament** (**labrum glenoidale**) is a wedge-shaped fibrocartilaginous rim situated upon the edge of the glenoid cavity and possessing a wide attachment and thin border; it is continuous superiorly with the long head of the biceps and inferiorly with the long head of the triceps. It deepens the glenoid cavity and protects both the edge of the cavity and the head of the humerus from the effects of sudden impacts and severe pressure.

The **synovial membrane** which lines the ligamentous walls of the joint is reflected upon the neck of the humerus and is continuous with the margin of the articular cartilage which covers the head of the humerus and the glenoid cavity of the scapula. It sends a reflection around the long tendon of the biceps where it lies within the capsule of the joint and above the head of the humerus, and communicates with a bursal sac, the *subscapular bursa*, situated between the capsule and the tendon of the subscapularis muscle, and occasionally with another bursal sac placed between the capsule and the tendon of the infraspinatus. A large bursa, the *subdeltoid*, or *subacromial, bursa* which only occasionally communicates with the shoulder-joint, lies between the deltoid muscle and the capsular ligament.

In **acute synovitis** of the shoulder-joint the synovial sac becomes distended with fluid, and as the synovial sac in relation with the long head of the biceps is a process of the synovial membrane of the joint, a fluctuating swelling may be detected upon each side of the biceps tendon. The arm is lengthened by the pressure of the fluid; it may be lifted into its normal position, but it immediately lengthens after the support is removed. There is always some degree of restriction of motion. Heat and tenderness are always present, but redness is rarely seen. Acute synovitis of the shoulder may be mistaken for inflammation of the subacromial bursa, as either condition may be caused by traumatism. In the former there is pain on moving the arm in any direction, whereas in inflammation of the acromial bursa the pain is much more marked in abduction of the arm, as this movement causes compression of the bursa.

The muscles protecting the joint are: the subscapularis, anteriorly; the supraspinatus and long tendon of the biceps, superiorly; the infraspinatus and teres minor posteriorly, and the long head of the triceps inferiorly. The deltoid covers the superior, posterior, and lateral aspects of the joint, and, while protecting it from direct injury, aids in the retention of the head of the humerus within its socket. The joint is also protected above by the acromio-clavicular arch and the coraco-acromial ligament. The long tendon of origin of the biceps

lying in an osteofibrous canal between the tuberosities of the humerus, strengthens the joint and supports the head of the humerus in its various movements.

Movement in all directions, affording gliding, anteduction, retroduction, adduction, abduction, and circumduction, is possible at the shoulder-joint. The most limited movements are backward and upward. Persistence in the former movement causes the scapula to recede toward the median line of the body, and, in the latter, the inferior scapular angle to rotate forward and laterally. In cases of ankylosis of the shoulder-joint the movement of the scapula compensates, to a certain extent, for the loss of motion in the scapulo-humeral articulation. Free movement in the shoulder-joint is permitted by the small glenoid cavity and the large rounded articulating surface of the head of the humerus and the laxity of the capsular ligament. Although the capsule is loose, pinching of the ligament or the synovial membrane rarely occurs, being prevented by the partial insertion of the subscapularis, supraspinatus, the infraspinatus and teres minor muscles into the capsular ligament.

Blood Supply.—From the subscapular, anterior and posterior circumflex, and suprascapular (*transverse scapular*) arteries.

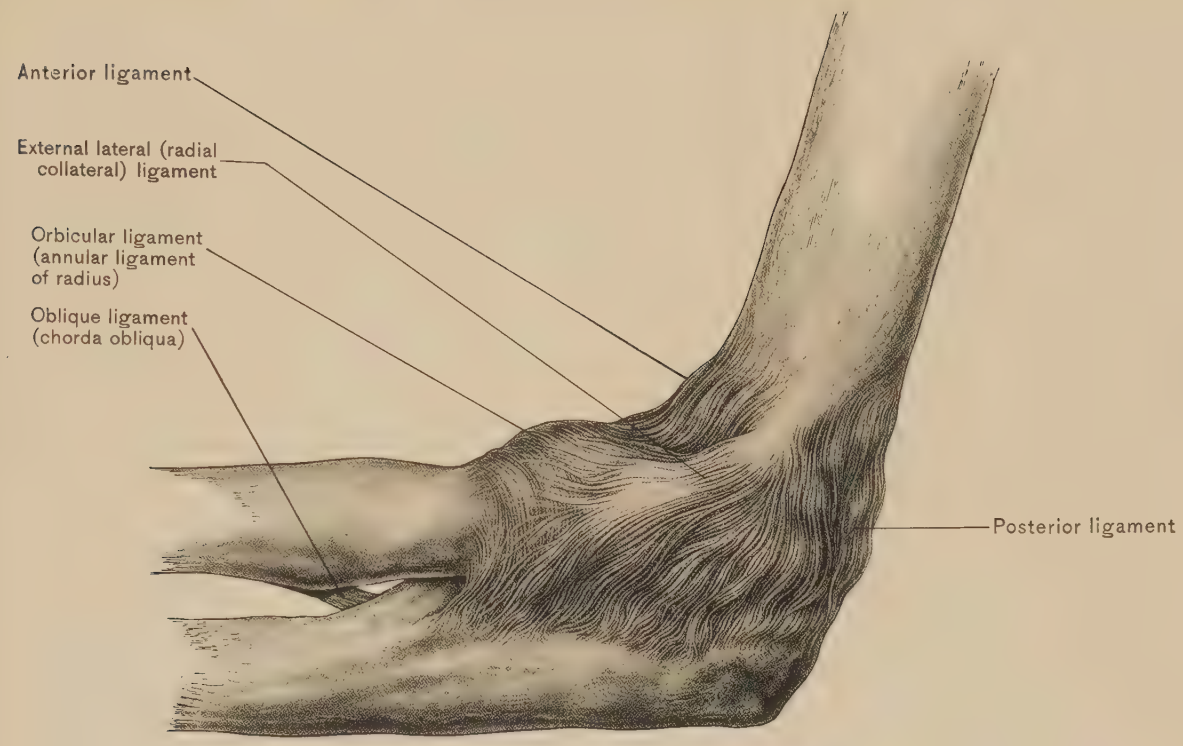
Nerve Supply.—From the circumflex (*axillary*) and suprascapular nerves.

THE ELBOW-JOINT (Plate CLXXX)

The **elbow** is a ginglymus or hinge-joint, and is formed by the contiguous articular surfaces of the humerus and the ulna and radius, together with their connecting ligaments. The distal end of the humerus is divided into two articular surfaces: a large medial one, the *trochlear surface*, articulating with the greater sigmoid cavity (*semilunar notch*) of the ulna; and a smaller lateral one, the *capitellum*, articulating with the head of the radius. The proximal end of the ulna, by its greater sigmoid cavity (*semilunar notch*) grasps the trochlear surface of the humerus like a monkey-wrench around a screw-nut; this can be seen after vertical section through the joint involving and dividing the olecranon and coronoid processes. While the head of the radius, through its concavity, glides forward and backward during movements of the ulna, the principal function of this articulation is to allow rotation of the head of the radius in pronation and supination of the forearm. Thus we find three different joints in one common articular capsule. For a discussion of the carrying angle see page 1.

The condyles (*epicondyles*) of the humerus, which give attachment to powerful muscles of the forearm, project beyond the elbow-joint upon each side. Posterior to the joint is the prominence of the olecranon, into which the tendon of the triceps is inserted; anterior to it at the base of the antecubital (*cubital*) fossa is found the coronoid process of the ulna, into the base of which the brachialis

PLATE CLXXX.



ELBOW JOINT—LATERAL VIEW.

ELBOW JOINT—MEDIAL VIEW.

is inserted. Deep within the lateral part of the fossa, is the tuberosity of the radius, into which the tendon of the biceps is inserted.

The bones are held in position by ligaments and muscles (the latter have already been fully described). The ligaments consist of the external lateral (*radial collateral*), the internal lateral (*ulnar collateral*), an anterior, and a posterior. These are all, in reality, portions of one capsular ligament which embraces the superior (*proximal*) radio-ulnar, in addition to the elbow-joint.

The **external lateral (radial collateral) ligament** is short and at its attachment to the lateral condyle (*epicondyle*) is narrow. It expands as it descends, and is attached to the orbicular ligament (*annular ligament of the radius*), which surrounds the head of the radius, to the neck of the radius and to the ulna, posterior to its lesser sigmoid cavity (*radial notch*). Its fibers are fused with the origin of the supinator brevis (*supinator*).

The **internal lateral (ulnar collateral) ligament** is triangular and is attached proximally by its apex to the medial condyle (*epicondyle*). Passing distally, it expands and is attached to the ulnar margin of the greater sigmoid cavity (*semilunar notch*). The ligament is in contact with the triceps and flexor carpi ulnaris muscles and the ulnar nerve.

The lateral ligaments are strong and tense, their function being to prevent displacement of bones and to limit movement. The presence of lateral movement indicates either a dislocation or disorganization of the joint by disease, usually tuberculous.

The **anterior ligament** extends across the front of the joint. It is attached to: the anterior surface of the humerus above the coronoid fossa, the anterior edge of the coronoid process, the anterior surface of the orbicular ligament (*annular ligament of the radius*), and the neck of the radius. It is continuous with the internal lateral (*ulnar collateral*) and external lateral (*radial collateral*) ligaments, and is covered by the brachialis muscle. This ligament assists in preventing over-extension.

The **posterior ligament** is a very thin layer extending from the proximal margin of the olecranon fossa to the superolateral margin of the olecranon process and to the orbicular ligament (*annular ligament of the radius*). Some of the deep fibers of the triceps are inserted into it and assist in drawing up the capsule when the triceps contracts.

A **synovial membrane** lines the joint surface of the ligaments, and is reflected upon the margins of the articulating surfaces of the bones which enter into the formation of the joint. It is widest and most loosely arranged beneath the tendon of the triceps muscle, as is demonstrated by the enlargement on each side of the triceps in case of synovitis with effusion into the joint. It is continu-

ous with the synovial sac of the proximal radio-ulnar joint. There is more or less adipose tissue between the capsule of the joint and the synovial membrane where the latter is reflected from the ligament to and upon the margins of the articulating surfaces, especially at the radial, coronoid, and olecranon fossæ.

Bursæ near the elbow-joint.—There is a small bursa over the head of the radius between the common extensor tendon of origin and the capsule; one between the tendon of the triceps and part of the proximal surface of the olecranon process; one between the tendon of the biceps and the anterior portion of the tuberosity of the radius, and one, the olecranon bursa, in the subcutaneous tissue over the olecranon. The olecranon bursa is often the site of disease (miner's elbow) which can be easily treated by excision, since the bursa does not communicate with the joint, in fact none of these bursæ communicates with the joint.

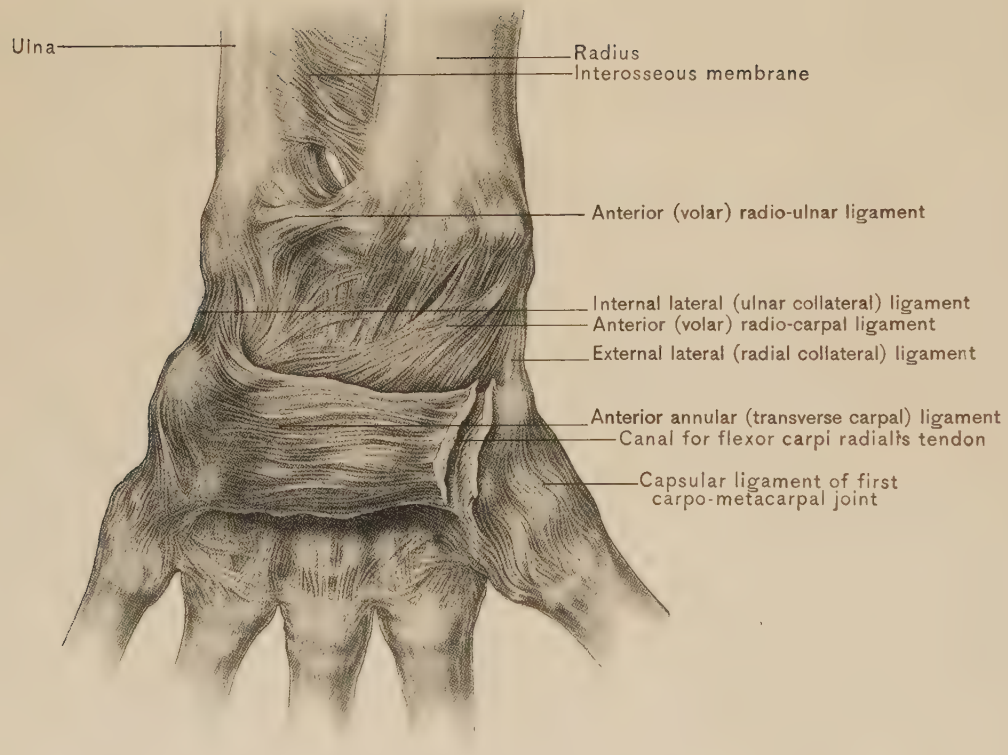
In **acute synovitis** of the elbow-joint the synovial sac is distended with fluid, and instead of a depression on each side of the olecranon and the tendon of the triceps, there is a swelling with an intermediate depression which corresponds in position to the above-mentioned tendon and the olecranon process.

Movements.—The movements of the elbow-joint consist only of flexion and extension; flexion is checked by the contact of the soft parts of the forearm and arm; extension, by the tightening of the ligamentous and muscular structures on the anterior aspect of the joint. It must be remembered that the movements of the proximal radio-ulnar articulation are entirely independent of those of the elbow-joint. The motion of the elbow-joint is purely a hinge movement, while that of the proximal radio-ulnar joint is rotatory. In flexion and extension of the forearm the head of the radius simply glides forward and backward upon the capitellum; in supination and pronation the head of the radius has a rotatory motion within its orbicular ligament (*annular ligament of the radius*) and the lesser sigmoid cavity (*radial notch*) of the ulna.

Blood Supply.—From the inosculating twigs of the superior profunda (*profunda brachii*) and inferior profunda (*superior ulnar collateral*), the anastomotica magna (*inferior ulnar collateral*), the anterior and posterior ulnar recurrent, the interosseous recurrent, and the radial recurrent arteries.

Nerve Supply.—From the ulnar nerve as it lies between the medial condyle (*epicondyle*) and the olecranon, from the musculo-spiral (*radial*), musculo-cutaneous, and median nerves.

PLATE CLXXXI.



INFERIOR (DISTAL) RADIO-ULNAR LIGAMENTS—ANTERIOR VIEW.

RADIO-ULNAR ARTICULATIONS

The movements of both pronation and supination of the forearm are possible through the articulations between the radius and the ulna. These bones, in reality, form two joints, a superior (*proximal*) and an inferior (*distal*), and are connected in three places, at the superior and inferior articulations and throughout the length of their shafts.

The **superior** (**proximal**) **radio-ulnar articulation,** (Plate CLXXX) a pivot, or rotatory, joint, is formed by the reception of the head of the radius into the lesser sigmoid cavity (*radial notch*) of the ulna. Only one ligament, the *orbicular* (*annular ligament of the radius*), is found at this joint. It encircles the head of the radius in the form of a complete ring, as it passes from the anterior to the posterior border of the lesser sigmoid cavity (*radial notch*). Its distal circumference is less than its proximal, so that it also suspends the head of the radius. It is intimately blended with the anterior, posterior, and external lateral (*radial collateral*) ligaments of the elbow-joint. The supinator brevis (*supinator*) muscle is afforded a partial origin from this ligament and helps to strengthen the joint.

The **synovial membrane** of this articulation is continuous with that of the elbow-joint.

Blood and Nerve Supply.—From the same sources as those of the elbow-joint.

The **inferior** (**distal**) **radio-ulnar articulation** (Plate CLXXXI), a lateral hinge-joint, is formed by the reception of the head (*distal end*) of the ulna into the sigmoid cavity (*ulnar notch*) situated on the ulnar side of the base of the radius. A thin layer of cartilage covers the articular surfaces of the bones. The ligaments of the joint are the anterior (*volar*) and posterior (*dorsal*) radio-ulnar and the triangular fibrocartilage (*articular disc*).

The **anterior** (**volar**) **radio-ulnar ligament** is narrow, and passes from the anterior border of the sigmoid cavity of the radius (*ulnar notch*) to the anterior surface of the head of the ulna.

The **posterior** (**dorsal**) **radio-ulnar ligament** is similarly attached to the back of the joint. Both radio-ulnar ligaments consist of thin fibers and are long enough to allow pronation and supination of the radius.

The **triangular fibrocartilage** (**articular disc**) separates the inferior (*distal*) radio-ulnar articulation from the wrist. Its lower surface is a continuation medialward of the radial articular surface. It is attached by its apex to the depression at the base of the styloid process of the ulna, and by its base to the distal end of the radius, along the lower margin of the sigmoid cavity (*ulnar notch*), and by its margin is united to the carpal ligaments. Its apex is thick and its

base thin; it is concave proximally, and thicker at its edges than at its center. Sometimes the center is perforated, and the synovial sac of this joint is then continuous with that of the wrist-joint. When, from traumatism or disease, this cartilage becomes detached from the radius, the resulting deformity is an abnormal projection of the head of the ulna, a condition frequently encountered as a complication and sequel of Colles' fracture.

The **synovial membrane** of this joint is so loose that it has been aptly called the sacciform membrane; this laxity is necessary to permit the rotation of the base of the radius about the head of the ulna during pronation and supination. The triangular fibrocartilage (*articular disc*) follows the base of the radius in its movements around the head of the ulna.

Blood Supply.—From the anterior (*volar*) interosseous artery and the anterior (*volar*) carpal arch.

Nerve Supply.—From the anterior (*volar*) and posterior (*dorsal*) interosseous nerves.

The shafts of the radius and ulna are also connected by the oblique ligament (*chorda obliqua*) and the interosseous membrane of the forearm.

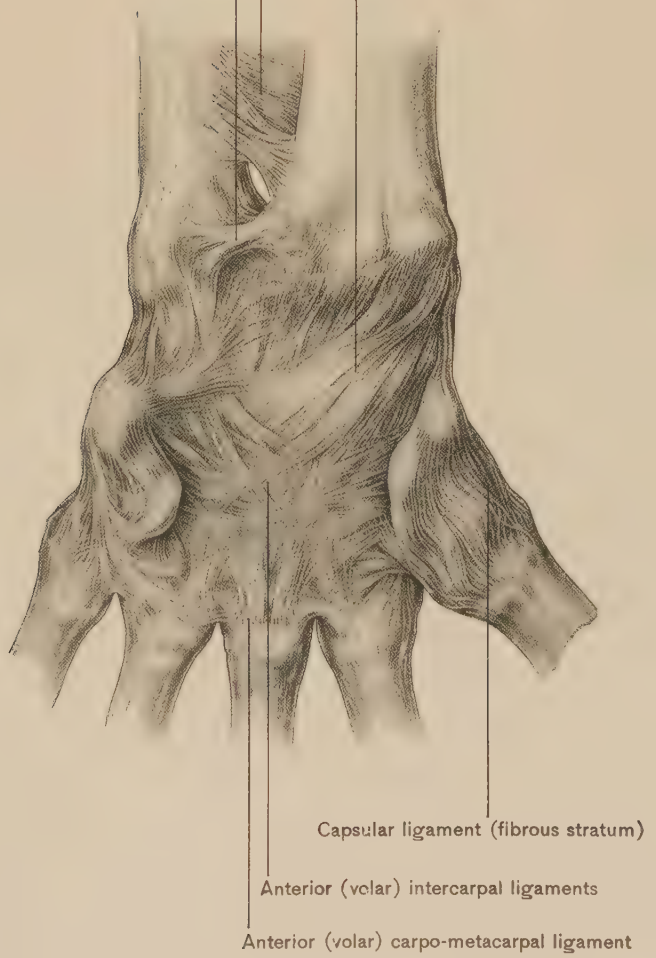
The **oblique ligament** (**chorda obliqua**), often absent, is a round slip which passes in a downward and lateral direction from the lateral part of the coronoid process of the ulna to the radius below the tuberosity. It lies above the proximal border of the interosseous membrane, its fibers running at a right angle to those of the membrane.

The **interosseous membrane** of the forearm is attached to the interosseous crests of the radius and ulna, and stretches across the interval existing between these bones. It is deficient above, leaving a gap, the *hiatus interosseous*, between its proximal border and the oblique ligament (*chorda obliqua*), through which the posterior (*dorsal*) interosseous vessels pass to the back of the forearm. The anterior (*volar*) interosseous vessels pass through an opening located near the distal end of this membrane to reach the back of the forearm. The interosseous membrane, whose fibers run obliquely downward from the radius to the ulna, helps to hold the bones together, and anteriorly gives a greater surface for the origin of the flexor digitorum profundus and the flexor pollicis longus muscles, and posteriorly, for the origin of the three extensors of the thumb and the extensor indicis (*extensor indicis proprius*).

THE RADIO-CARPAL ARTICULATION (Plates CLXXXII; CLXXXIII)

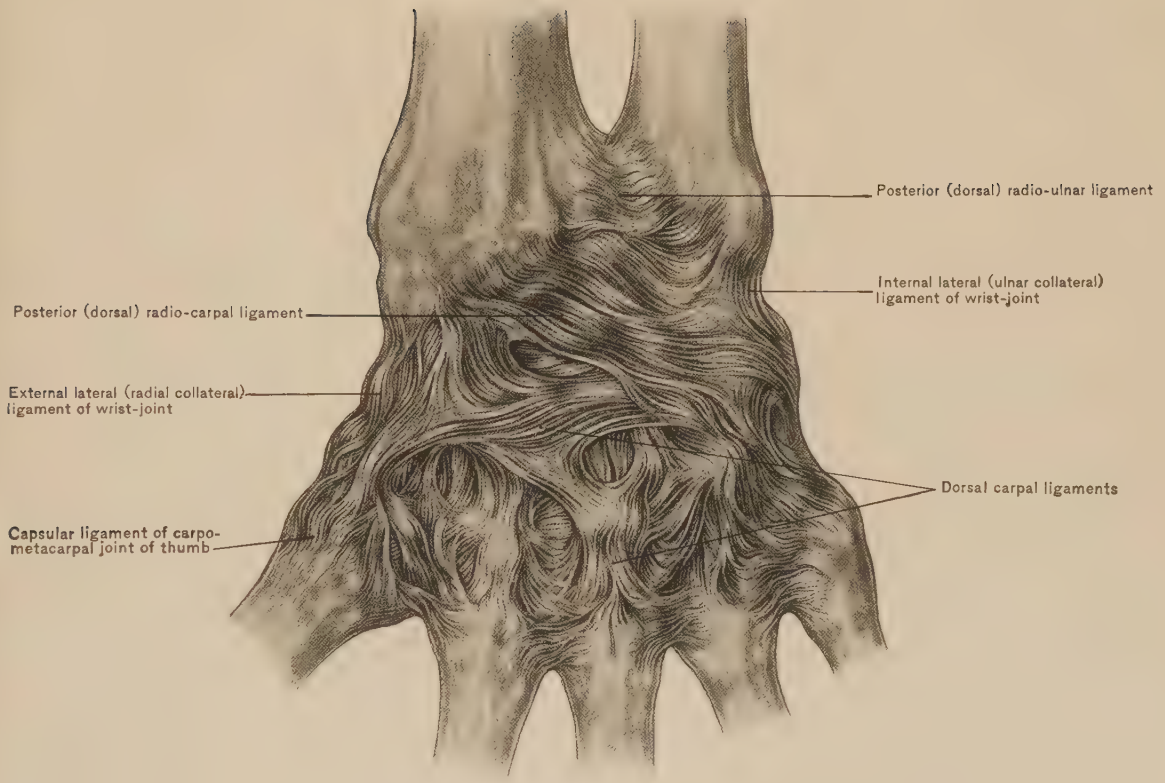
The **radio-carpal** articulation, or wrist, a double ginglymus or condyloid joint, is formed proximally by the distal end of the radius and the under surface of the triangular fibrocartilage (*articular disc*), and distally by the scaphoid (*navic-*

PLATE CLXXXII.



INFERIOR (DISTAL) RADIO-ULNAR, RADIO-CARPAL, INTERCARPAL, AND CARPO-METACARPAL LIGAMENTS—ANTERIOR VIEW.

PLATE CLXXXIII.


Posterior (dorsal) radio-ulnar ligament
Internal lateral (ulnar collateral) ligament of wrist-joint
Posterior (dorsal) radio-carpal ligament
External lateral (radial collateral) ligament of wrist-joint
Dorsal carpal ligaments
Capsular ligament of carpo-metacarpal joint of thumb

INFERIOR (DISTAL) RADIO-ULNAR, RADIO-CARPAL, INTERCARPAL, AND CARPO-METACARPAL LIGAMENTS—POSTERIOR VIEW.

ular), semilunar (*lunatum*), and cuneiform (*triquetrum*) bones of the carpus. The ulna is separated from the joint by the triangular fibrocartilage (*articular disc*), and therefore does not enter into its formation. The distal end of the radius, with the triangular fibrocartilage (*articular disc*), forms a concave surface into which the three bones of the carpus, which form a smooth, convex surface, are received. The surfaces of the bones entering into the formation of the wrist-joint are covered with cartilage and firmly held in apposition by four ligaments: external lateral (*radial collateral*), internal lateral (*ulnar collateral*), anterior (*volar radio-carpal*), and posterior (*dorsal radio-carpal*).

The **external lateral** (**radial collateral**) **ligament** extends from the tip of the styloid process of the radius to the lateral side of the scaphoid (*navicular*). A few of its fibers radiate slightly to the tubercle of the scaphoid (*navicular*) and the ridge of the trapezium (*multangulum majus*), while others pass to the dorsal surface of the scaphoid (*navicular*). The external lateral (*radial collateral*) ligament is in relation with the radial artery and the tendons of the extensores ossis metacarpi pollicis (*abductor pollicis longus*) and primi internodii pollicis (*extensor pollicis brevis*); the artery lies between the tendons and the ligament.

The **internal lateral** (**ulnar collateral**) **ligament** is attached to the extremity of the styloid process of the medial surface of the cuneiform bone (*triquetrum*), the pisiform bone, and the anterior annular (*transverse carpal*) ligament. It is fan-shaped, its fibers radiating to a more marked degree than those of the external lateral (*radial collateral*) ligament. The distal part of the ligament can readily be divided into two fasciculi, one of which passes to the medial side of the cuneiform bone (*triquetrum*), the other to the pisiform bone and the anterior annular (*transverse carpal*) ligament.

The tendon of the extensor carpi ulnaris passes over the posterior part of the ligament.

The **anterior** (**volar radio-carpal**) **ligament** is a broad, thick membrane which is attached proximally to the distal end of the radius, to its styloid process, to the triangular fibrocartilage (*articular disc*), and to the ulna; distally to the palmar surface of the scaphoid (*navicular*), semilunar (*lunatum*), and cuneiform (*triquetrum*) bones. A few of the fibers are continued distally to the os magnum (*capitatum*) and the unciform (*hamatum*). The tendons of the flexor digitorum profundus and the flexor pollicis longus are in relation with the anterior surface of the ligament, and the synovial membrane of the joint is in contact with its posterior surface. Numerous small vessels pierce the ligament.

The **posterior** (**dorsal radio-carpal**) **ligament,** weaker than the anterior, extends from the posterior surface of the distal end of the radius and the triangular fibrocartilage to the posterior surface of the scaphoid (*navicular*), semilunar

(*lunatum*), and cuneiform (*triquetrum*) bones. It is strengthened by fibers from the back of the fibrocartilage (*articular disc*), and also by the fibrous sheaths of the extensor secundi internodii pollicis (*extensor pollicis longus*) and the radial extensors. The other extensor tendons, which are in relation with the posterior surface of the ligament, also add to its strength. The anterior surface is in relation with the synovial membrane.

A **synovial membrane** lines the ligaments of the joint from which it is reflected to the margins of the articular surfaces entering into the formation of the joint. It is very lax on account of the free movement of the joint. It does not communicate with the inferior (*distal*) radio-ulnar joint, except when the triangular fibrocartilage (*articular disc*) is perforated, and, owing to the intervention of the interosseous ligaments, also does not communicate with the carpal joints.

In **acute synovitis** of the wrist-joint there is pain, and, as the joint is superficial, heat and redness are also present. The swelling is apt to be most pronounced on the dorsal surface, where the subcutaneous tissue is more loosely arranged; there may also be bulging between the extensor tendons. Acute synovitis is differentiated from tenosynovitis, or inflammation of the sheaths of the tendons, by the fact that in the former, when the wrist-joint is fixed, the fingers can be moved without producing pain, while in tenosynovitis, movements of the fingers are painful.

In front of the wrist-joint are the flexor tendons of the hand, and behind are the extensors. The numerous tendons which pass over the wrist-joint, and the fibrous extensions from their sheaths, serve to strengthen this otherwise poorly protected articulation.

Movements.—The movements of the wrist-joint are very similar to those of a ball-and-socket joint, the main difference being that the wrist has no power of rotation, a loss which is overcome by the pronation and supination of the forearm, made possible through the radio-ulnar articulations. A combination of these movements produces circumduction. The hand can be flexed and extended through an arc of 140° and abducted and adducted about half as much.

Blood Supply.—From the anterior (*volar*) and posterior (*dorsal*) carpal arches, the anterior (*volar*) and posterior (*dorsal*) interosseous, and the recurrent carpal branches of the deep palmar (*deep volar*) arch.

Nerve Supply.—From the ulnar and the posterior (*dorsal*) interosseous nerves.

Dissection.—To expose the articular surfaces of the joint, cut the anterior and lateral ligaments transversely and strongly extend the hand.

THE CARPAL JOINTS (INTERCARPAL ARTICULATIONS) (Plates CLXXXII; CLXXXIII)

The articulations of the bones of the carpus are divided into four sets: those between the bones of the proximal row, those between the bones of the distal row, the articulation between these two rows, and the pisiform articulation.

The ligaments of the proximal row of carpal bones are two dorsal (*dorsal intercarpal*), two palmar (*volar intercarpal*), two interosseous fibrocartilages (*interosseous intercarpal*), and the capsular ligament connecting the pisiform and cuneiform (*triquetrum*) bones.

The **two dorsal** (**dorsal intercarpal**) **ligaments** connect the dorsal surfaces of the bones, the scaphoid (*navicular*) with the semilunar (*lunatum*), and the semilunar (*lunatum*) with the cuneiform (*triquetrum*).

The **two palmar** (**volar intercarpal**) **ligaments** connect the anterior surfaces of the same bones. The palmar ligaments are stronger than the dorsal.

The **interosseous** (**interosseous intercarpal**) **fibrocartilages** are two strips of cartilage which connect the adjacent surfaces of the scaphoid (*navicular*) and semilunar (*lunatum*), and the semilunar (*lunatum*) and cuneiform (*triquetrum*). They fill in the interstices between the bones and help to form the smooth convex surface for articulation with the radius and the triangular fibrocartilage (*articular disc*).

The pisiform bone is attached to the cuneiform (*triquetrum*) by a *capsular ligament*, which has a separate *synovial membrane*. The pisiform is also attached to the unciform (*hamatum*) by a strong palmar band, the *piso-uncinate* (*piso-hamate*) *ligament*, and to the base of the fifth metacarpal bone by another strong palmar band, the *piso-metacarpal ligament*. These palmar bands may be regarded as prolongations from the tendon of the flexor carpi ulnaris, and the pisiform as a sesamoid bone in that tendon.

The ligaments of the distal row of carpal bones are three dorsal, three palmar, and two, sometimes three, interosseous.

The **three dorsal** (**dorsal intercarpal**) **ligaments** connect the dorsal surfaces of the bones of the distal row: the trapezium (*multangulum majus*) with the trapezoid (*multangulum minus*), the trapezoid (*multangulum minus*) with the os magnum (*capitatum*), and the os magnum (*capitatum*) with the unciform (*hamatum*).

The **three palmar** (**volar intercarpal**) **ligaments** connect the palmar surfaces of the bones of the distal row in the same manner as the dorsal ligaments. The palmar ligaments are stronger than the dorsal.

The **two interosseous** (**interosseous intercarpal**) **ligaments** connect the unciform (*hamatum*) with the os magnum (*capitatum*) and the os magnum with the

trapezoid (*multangulum minus*). Sometimes there is a third interosseous ligament found between the trapezium (*multangulum majus*) and the trapezoid (*multangulum minus*).

The **synovial membrane** is an extension of the membrane which lines the joint between the proximal and distal rows, or the medio-carpal joint.

The **mediocarpal (midcarpal) articulation** is situated between the two rows of carpal bones. The line of articulation is composed of three distinct parts: on the lateral side, the scaphoid (*navicular*) of the first row articulates with the trapezium (*multangulum majus*) and the trapezoid (*multangulum minus*) of the second row; intermedially, the scaphoid (*navicular*) and the semilunar (*lunatum*) of the first row form a cup-shaped cavity into which the head of the os magnum (*capitatum*) and the superior margin of the unciform (*hamatum*) of the second row are received; on the medial side, the cuneiform (*triquetrum*) of the first row articulates with the unciform (*hamatum*) of the second. The two rows of the carpus are held in place by four ligaments: the anterior mediocarpal (*volar intercarpal*), the posterior mediocarpal (*dorsal intercarpal*), and two lateral ligaments.

The **anterior mediocarpal (volar intercarpal) ligaments** connect the palmar (*volar*) surfaces of the bones of the first row with those of the second. Most of the fibers extend from the first row to the os magnum (*capitatum*), some connect the scaphoid (*navicular*) to the trapezium (*multangulum majus*) and the trapezoid (*multangulum minus*), and others pass from the cuneiform (*triquetrum*) to the unciform (*hamatum*).

The **posterior mediocarpal (dorsal intercarpal) ligament** consists of fibers which pass obliquely from the first to the second row. They are not uniform throughout, being stronger on the ulnar side.

The **external lateral (radial collateral carpal) ligament** connects the scaphoid (*navicular*) with the trapezium (*multangulum majus*).

An **interosseous ligament** is occasionally found within the capsule, connecting the os magnum (*capitatum*) and the scaphoid (*navicular*).

The **internal lateral (ulnar collateral carpal) ligament** connects the cuneiform (*triquetrum*) with the unciform (*hamatum*).

The **synovial membrane** of the carpus lines the mediocarpal joint and sends two prolongations upward between the scaphoid (*navicular*) and semilunar (*lunatum*) and the semilunar (*lunatum*) and cuneiform (*triquetrum*), and three downward; the latter line the joints of the second row, the carpo-metacarpal joints of the four medial metacarpal bones, and the joints between the bases of the latter. It is thus seen that the joints of the carpus, with the exception of the pisiform, communicate, so that a suppurative process originating at one point can travel between all the carpal (except the pisiform) and the metacarpal bones.

Movements of the carpal joints are limited, to a great extent, to flexion and extension, although there is an anteroposterior gliding motion, and a very slight degree of rotation between the articulation of the os magnum (*capitatum*)with the scaphoid (*navicular*) and the semilunar (*lunatum*).

Blood Supply.—From the anterior (*volar*) and posterior (*dorsal*) carpal branches of the radial and ulnar arteries, the anterior (*volar*) interosseous, and the recurrent carpal branches of the deep palmar (*deep volar*) arch.

Nerve Supply.—From the ulnar, the median, and the posterior (*dorsal*) interosseous nerves.

Dissection.—To expose the articulating surfaces of the mediocarpal joint and the interosseous ligaments divide the dorsal and lateral ligaments and strongly flex the hand.

CARPO-METACARPAL ARTICULATIONS (Plates CLXXXII; CLXXXIII)

The articulations between the carpal and metacarpal bones may be divided into two sets: the junction of the proximal ends of the second to fourth metacarpal bones with the unciform (*hamatum*), os magnum (*capitatum*), and trapezoid (*multangulum minus*); and the articulation of the proximal end of the metacarpal bone of the thumb with the trapezium (*multangulum majus*).

In the **First Set** the metacarpal bone of the index finger articulates with the trapezoid (*multangulum minus*), that of the middle finger with the os magnum (*capitatum*), and that of the ring and of the little finger with the unciform (*hamatum*). The ligaments connecting the bones are dorsal, palmar, and interosseous.

The **dorsal (dorsal carpo-metacarpal) ligaments** are stronger and more distinct than the palmar. They connect the dorsal surface of the respective carpal bones with the dorsal surface of the metacarpal bones. Two fasciculi extend from each of the metacarpal bones except that of the little finger. From the index finger one extends from the trapezium (*multangulum majus*), the other from the trapezoid (*multangulum minus*); from the middle finger one from the trapezoid and one from the os magnum (*capitatum*); from the ring finger one from the os magnum (*capitatum*) and one from the unciform (*hamatum*); while from the little finger there is only one, from the unciform (*hamatum*).

The **palmar (volar carpo-metacarpal) ligaments** are somewhat similar to the dorsal. The metacarpal bone of the index finger has one fasciculus, from the trapezium (*multangulum majus*), under cover of the flexor carpi radialis; that of the middle finger has three fasciculi: one from the os magnum (*capitatum*), one from the trapezium (*multangulum majus*), and a third from the unciform (*hamatum*) and the base of the fifth metacarpal; the ring and little fingers have one each, from the unciform (*hamatum*).

The **interosseous ligaments** are found only in one part of the joint. They connect the adjacent angles of the unciform (*hamatum*) and os magnum (*capitatum*) with the metacarpal bones of the middle and ring fingers.

The **synovial membrane** is a continuation of the membrane lining the mediocarpal joint. Sometimes there is a separate synovial lining for the articulation of the unciform (*hamatum*) with the fourth and fifth metacarpal bones.

Movements of the carpo-metacarpal joint of the four medial metacarpal bones are slight; those of the little finger are most free, followed by that of the ring finger. The articulations of the index and middle fingers are almost immovable.

Blood Supply.—The carpo-metacarpal joint of the index finger is nourished by the radial, the dorsal metacarpal, the dorsalis indicis (*dorsal metacarpal*), and the radialis indicis (*volaris indicis radialis*) arteries; of the middle and ring fingers, by the anterior (*volar*) and posterior (*dorsal*) carpal arches and the deep palmar (*deep volar*) arch; of the little finger, by the ulnar artery and its deep branch and the posterior (*dorsal*) carpal arch.

Nerve Supply.—From the deep palmar (*deep volar*) branch of the ulnar, from the median and posterior (*dorsal*) interosseous nerves.

The **Second Set** consists of the articulation between the metacarpal bone of the thumb and the trapezium (*capitatum*).

The **ligament** is a loose capsule which extends from the margin of the articular surface of the trapezium (*capitatum*) to that of the metacarpal bone. It is stronger on its dorsal aspect. It is strengthened by palmar, dorsal, lateral, and medial fibrous bands, the last named being the strongest.

The **synovial membrane** is separate from that of the carpal and the other carpo-metacarpal joints.

Movements.—The shape of the articulating surfaces of the bones of the carpo-metacarpal joint of the thumb allows flexion and extension; abduction and adduction, and a certain amount of rotation.

Blood Supply.—From the radial, dorsalis pollicis (*first dorsal metacarpal*) and princeps pollicis arteries.

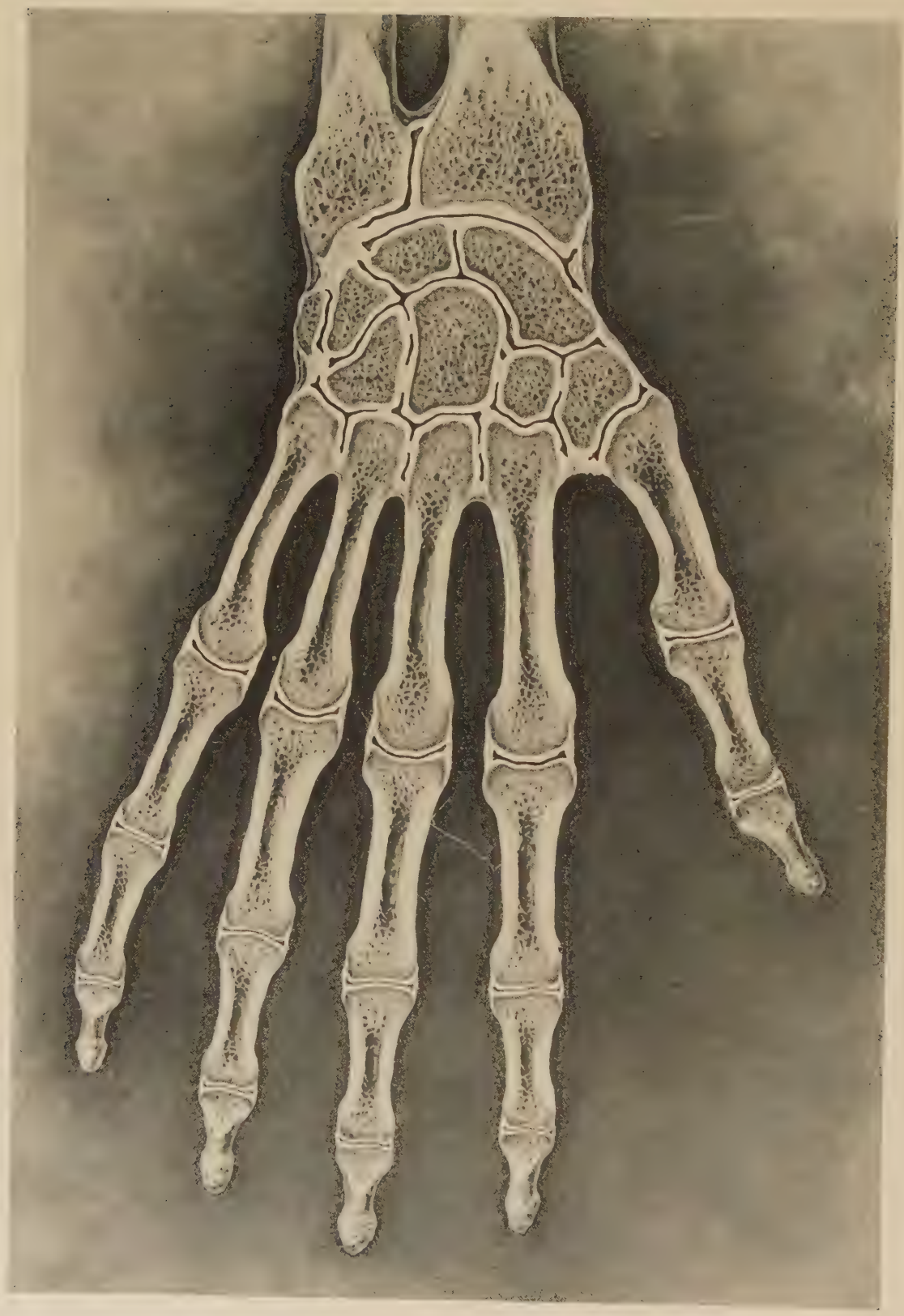
Nerve Supply.—From branches of the median nerve.

THE INTERMETACARPAL ARTICULATIONS (Plate CLXXXIII)

The metacarpal bones of the four fingers are held together at each end by ligaments. The lateral articular surfaces at their carpal extremities are held in apposition by dorsal, palmar, and interosseous ligaments.

The **dorsal and palmar ligaments** are attached to the respective surfaces of the bones.

PLATE CLXXXIV.



SECTION OF JOINTS OF WRIST AND HAND.

The **interosseous ligaments** pass between the distal margins of the adjacent articulating surfaces.

The **synovial membranes** of these joints are extensions of the common carpal synovial membrane.

Blood Supply.—From twigs of the palmar interosseous (*volar metacarpal*) and dorsal interosseous (*dorsal metacarpal*) arteries.

Nerve Supply.—From the ulnar and posterior (*dorsal*) interosseous nerves.

The distal extremities, or heads, of the four medial metacarpal bones are held in place by the **transverse metacarpal ligament,** situated on the anterior or palmar surface. This is a fibrous band consisting of three fasciculi, which connect the second and third, the third and fourth, and the fourth and fifth bones. It blends with the glenoid (*volar accessory*) ligament of the metacarpo-phalangeal articulations. The interosseous muscles pass behind it to reach their points of insertion, while the digital arteries and nerves and the flexor tendons and lumbricales muscles pass in front of it. The distal end of the metacarpal bone of the thumb is not connected with any other metacarpal bone.

THE METACARPO-PHALANGEAL ARTICULATIONS (Plate CLXXXIV)

The heads of the metacarpal bones are received into a cup-shaped cavity on the proximal end or base of the corresponding phalanx. They are held in place by an anterior, or glenoid (*volar accessory*), and two lateral (*collateral*) ligaments.

The **anterior, or glenoid (volar accessory), ligament** is a dense, fibrous plate which is firmly attached to the base of the first phalanx and loosely attached, by areolar tissue, to the head of the metacarpal bone. It deepens the articular surface of the base of the phalanx. Its margins are continuous with the lateral (*collateral*) ligaments, the transverse metacarpal ligament, and the fibrous sheath of the flexor tendon.

The **lateral (collateral) ligaments** are strong short bands, situated on each side of the joint, that connect the tubercle and the depression on the side of the head of the metacarpal bone to the base of the phalanx. Anteriorly, they are continuous with the anterior (*volar accessory*) ligament and posteriorly, with the expansion of the extensor tendon.

The **synovial membrane** is very loose.

Posteriorly, the joint is covered by an expansion of the extensor tendon, which serves the purpose of a dorsal ligament.

Movements of these joints are flexion, extension, adduction, abduction, and circumduction.

Blood Supply.—From the digital (*common volar digital*) and palmar interosseous (*volar metacarpal*) arteries.

Nerve Supply.—From the digital nerves.

The metacarpo-phalangeal joint of the thumb differs from the corresponding joints of the other fingers, on account of the shape of the articulating surfaces. The head of the metacarpal bone of the thumb is wider than the heads of the metacarpal bones of the fingers, and instead of being rounded, has an irregularly raised palmar edge, upon which are two facets for the sesamoid bones. The ligaments are two lateral (*collateral*) and a posterior (*dorsal*). The *lateral* (*collateral*) ligaments are short, fibrous bands which connect the adjacent ends of the articulating bones. The *posterior* (*dorsal*) ligament consists of scattered fibers which pass across the joint and connect the two lateral (*collateral*) ligaments, completing the *articular capsule* and protecting the synovial membrane.

The **sesamoid bones,** two in number, rest on the facets on the head of the metacarpal bone of the thumb in the tendon of the flexor pollicis brevis. They are connected by transverse fibers which cover the front of the joint.

Blood Supply.—From the princeps pollicis and dorsalis pollicis.

Nerve Supply.—From the digital branches of the median and radial nerves.

THE INTERPHALANGEAL ARTICULATIONS (Plate CLXXXV)

The ligaments of the interphalangeal articulations consist of an anterior, or glenoid, and two lateral (*collateral*) ligaments.

The **anterior, or glenoid, ligament** (**volar portion of articular capsule**), like that of the metacarpo-phalangeal joint, is loosely attached to the proximal bone, but very firmly to the distal. It blends with the lateral (*collateral*) ligaments. The flexor tendons pass over the anterior ligament.

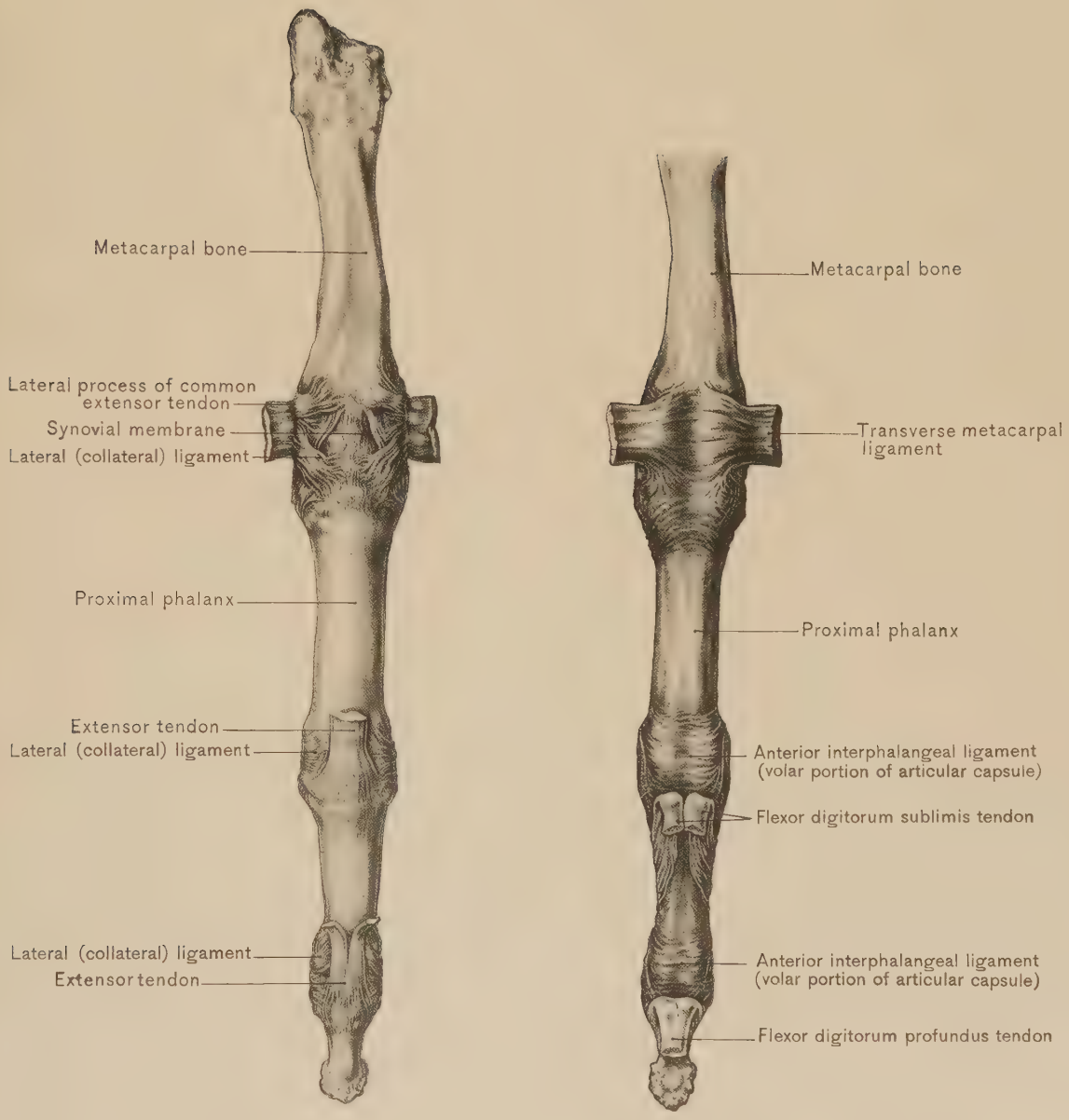
The **two lateral** (**collateral**) **ligaments** are strong bands which connect the sides of the proximal phalanx with the lateral aspect of the distal phalanx.

Posteriorly, the extensor tendon covers the joint and takes the place of a posterior (*dorsal*) ligament. The tendon blends with the lateral (*collateral*) ligaments to complete the articular capsule around the joint.

The **synovial membranes** of these joints are lax.

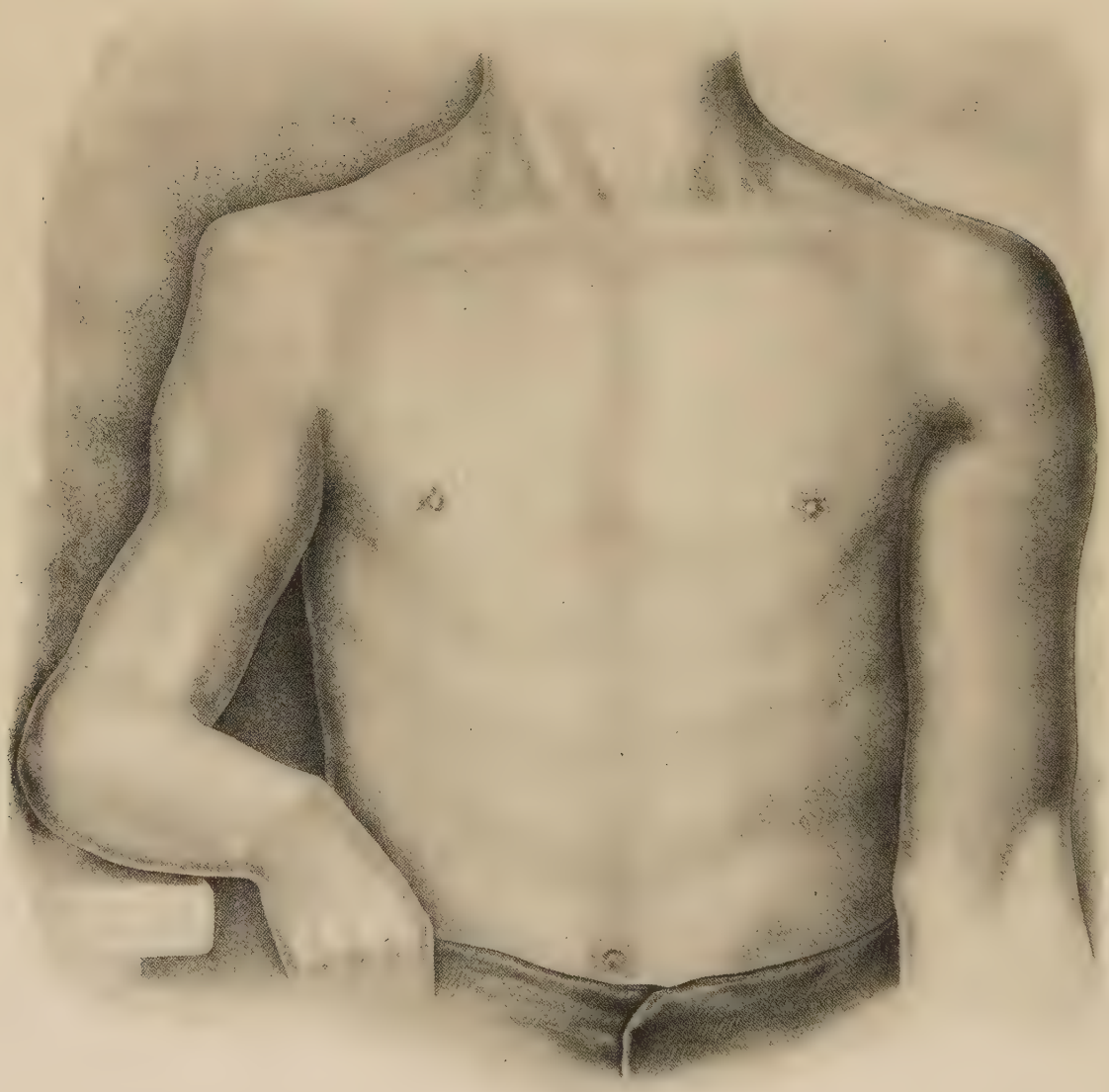
Movements of the interphalangeal joints are limited to extension and flexion. Flexion is much more free than extension because of the larger articulating surface in front of the heads of the proximal bones and the direction of the fibers of the lateral (*collateral*) ligaments which pass slightly forward to be inserted into the distal bone.

PLATE CLXXXV.



METACARPO-PHALANGEAL AND INTERPHALANGEAL LIGAMENTS (MIDDLE FINGER).

PLATE CLXXXVI.



DISLOCATED SHOULDER AND NORMAL SHOULDER.

Blood Supply.—From the collateral digital arteries.
Nerve Supply.—From the collateral digital nerves.

DISLOCATIONS

The description of the ligaments of the various joints makes it evident that the bones forming the articulations are so firmly held in place that luxation, or dislocation, is almost impossible without tearing one or more of the ligaments. But sometimes the tissues surrounding the joint may become so lax and so stretched that without rupture of any of the ligaments they may allow a displacement of the bones composing the joint. The muscles play a very important part in the reduction of luxations. By manipulating the dislocated member so as to give the muscles the opportunity to return to their normal condition from the overstretched state caused by the luxation, the displaced member can more easily be reduced.

Dislocations should be reduced as soon as possible after the injury. After swelling and inflammation have developed reduction is more difficult, and furthermore, early reduction lessens the chance of subsequent disability.

The **clavicle may be dislocated** at either end. Luxations at the sternal end are usually forward; upward or backward displacements are rare. In complete luxation of the sterno-clavicular joint the anterior and posterior sterno-clavicular as well as the interclavicular ligaments may be ruptured. The costo-clavicular ligament remaining intact prevents wider displacement of the bone. The interarticular fibrocartilage (*interarticular disc*) may remain attached to the sternum, but more often it is carried out with the clavicle. In upward dislocations the end of the bone passes behind the sternal origin of the sterno-mastoid muscle. In backward dislocations symptoms of pressure on the trachea and esophagus may occur.

Dislocation of the clavicle at the acromial end is much more frequent than at the sternal end, and is usually upward, although it may also be downward. The base of the coracoid process on which the clavicle rests acts as a fulcrum. In most cases there is only a partial dislocation. The capsular ligament formed by the superior and inferior acromio-clavicular ligaments is torn, while the conoid and trapezoid ligaments, though remaining intact, are stretched. In complete luxation the conoid and trapezoid ligaments are wholly or partially torn. The trapezius muscle then tends to pull the acromial end of the clavicle upward, section of the fibers of the trapezius often being required to allow the reduction to be maintained.

Dislocations of the humerus (Plate CLXXXVI) are very frequent, owing to the great freedom of motion at the shoulder, the exposed position of the joint,

and because the joint depends for its strength chiefly upon the elasticity and tonic contraction of the surrounding muscles. Consequently, when the muscles are relaxed and force is suddenly applied directly to the joint by a blow upon the shoulder, or indirectly by a fall upon the hand or the elbow, the head of the humerus slips out of the glenoid cavity. In abduction the greater tuberosity approximates the acromion process, and when hyperabduction occurs the acromion process acts as a fulcrum, the head of the bone being thrown out of the glenoid cavity. Four varieties of luxation are usually described: three anterior—subglenoid, subcoracoid, and subclavicular; and one posterior—subspinous.

In *subglenoid luxation* the head of the humerus makes its escape from the glenoid cavity by tearing through the inferior part of the capsular ligament. The head of the humerus is then found in the axilla, resting upon the triangular part of the axillary border of the scapula, immediately below and a little in front of the glenoid cavity and between the tendon of the subscapularis and that of the long head of the triceps muscles. The superior part of the capsule is tightly stretched across the glenoid cavity. In many cases the tendon of the long head of the biceps will be torn. The muscles attached to the tuberosities of the humerus are put on the stretch or are lacerated. Thus, the supraspinatus muscle is stretched or lacerated; the infraspinatus, subscapularis, and coracobrachialis muscles are generally put on the stretch; the deltoid muscle is in extreme tension and draws the elbow away from the body causing the sign familiarly known as Dugas' sign; the teres major and the teres minor are relaxed. The rotundity of the shoulder is lost, and a flatness is present owing to the displacement of the greater tuberosity, which creates an undue prominence of the acromion process and causes the formation of a transverse depression below it. The circumflex (*axillary*) nerve, which curves over the inferior margin of the subscapularis muscle and around the surgical neck of the humerus, is liable to injury, producing paralysis of the deltoid and teres minor. Atrophy of the deltoid may also be caused by disuse, as in ankylosis of the shoulder-joint, but more frequently by diseases of the spinal cord, as acute anterior poliomyelitis; by neuritis of the circumflex (*axillary*) nerve, usually due to disease of the shoulder-joint and causing paralysis of the deltoid and teres minor muscles, and also by injury of the circumflex (*axillary*) nerve by a blow upon, or a fracture of the proximal part of the humerus. On account of the relation of the contents of the axilla to the head of the dislocated humerus, there may be injury to the nerves and vessels of this space; the axillary artery or vein may be ruptured; and excessive stretching of the brachial plexus of nerves may lead to partial paralysis following the dislocation. Dislocation of the humerus and fracture of the anatomic neck of the scapula are the only injuries about the shoulder in which the arm

is lengthened. It is only rarely that a subglenoid position is maintained, the head of the bone usually coming to rest under the coracoid process.

In *subcoracoid luxation*, the most frequent luxation, the head of the bone escapes through a tear in the antero-inferior part of the capsule, and rests below the coracoid process upon the anterior surface of the neck of the scapula. There is, generally, injury to the coraco-brachialis and the short head of the biceps brachii, the conjoined tendon of origin of which muscles will be found to rest on the anterior surface of the head of the bone.

In *subclavicular luxation* the head of the bone escapes also through a rent in the antero-inferior portion of the capsule, and rests below the clavicle against the chest, beneath the pectoralis major and minor muscles. In both subcoracoid and subclavicular luxation the deltoid is greatly stretched, and the subscapularis is carried upward, with occasional rupture of its attachment to the lesser tuberosity of the humerus. The infraspinatus and supraspinatus muscles are stretched and, at times, lacerated. The long head of the biceps is often torn. The vessels and nerves of the axilla are carried forward with the head of the humerus, the consequent stretching of the nerves causing extreme pain. The circumflex (*axillary*) nerve, which curves over the inferior margin of the subscapularis muscle, may be severely injured by pressure, contusion, or laceration.

Anterior dislocations are produced by the arm being hyperabducted, rotated lateralward, and the head of the humerus being pushed or pulled medialward. The rotation causes the extensive laceration of the capsule. This laceration occurs in that portion of the capsule attached to the rim of the glenoid cavity, and not from its humeral attachment.

In *subspinous luxation* the head of the bone is forced through a rent in the postero-inferior part of the capsule, and rests upon the posterior surface of the capsule, below the spine of the scapula and beneath the infraspinatus muscle. This dislocation is rare. It occurs when the arm is abducted with strong medial rotation or by direct violence. The infraspinatus and the teres minor are stretched or torn. The tendon of the long head of the biceps and the anterior fibers of the deltoid will be stretched, but not ruptured.

In all *luxations of the head* of the humerus the *rotundity* of the shoulder is lost, owing to the displacement of the greater tuberosity; a depression appears at the normal site of the greater tuberosity. The head of the bone is found as a swelling in the location to which it has been displaced. *Flattening* of the shoulder in dislocation of the shoulder-joint must not be mistaken for atrophy of the deltoid muscle. In the latter condition the mobility and position of the head of the humerus and position of the tuberosities are normal.

In all forward, or anterior, luxations the elbow is carried away from the body by the resultant tension of the deltoid. The normal hollow below the lateral one-third of the clavicle is filled up. Dugas' sign is present, *e. g.*, the inability to bring the elbow on the injured side to the chest wall, if the hand is placed on the sound shoulder. In the subspinous luxation (posterior) the elbow is carried forward and to the side of the body by the pectoralis major and coracobrachialis muscles. In the reduction of shoulder-joint dislocations the axillary vein or artery, as well as the nerves in this locality, may be injured, unless great care is taken to avoid such an accident, especially if the lesion has existed for any time prior to treatment. The condition of the axillary artery should be determined. If it is atheromatous or included in dense connective tissue, formed during the associated inflammation, it may be ruptured in the attempt at reduction. The vessel which is more commonly ruptured, however, is the axillary vein. Fixation of the scapula is an important adjuvant in the reduction of dislocations of the humerus.

Dislocations at the elbow-joint may involve both the radius and the ulna, or either bone separately; dislocations of both bones may be backward, forward, medialward, or lateralward.

In the diagnosis of dislocations at the elbow the relation of the olecranon to the condyles (*epicondyles*) of the humerus, and the head of the radius to the lateral condyle (*epicondyle*), should be determined. Normally, when the forearm is extended, the tip of the olecranon is slightly above a line drawn between the condyles (*epicondyles*); when the forearm is flexed at a right angle, it is below the intercondyloid line, and in extreme flexion the olecranon is in a plane anterior to that line. The olecranon is nearer to the medial than to the lateral condyle (*epicondyle*); the distance between the medial margin of the olecranon and the medial condyle (*epicondyle*) being merely sufficient to accommodate the ulnar nerve. The head of the radius during pronation and supination is felt rotating just below the lateral condyle (*epicondyle*) of the humerus.

In *backward luxation* of both bones, the most common dislocation at the elbow, the proximal extremities of the bones are carried so far backward that the coronoid process of the ulna rests in the olecranon fossa of the humerus, and the head of the radius lies behind the lateral humeral condyle (*epicondyle*). This dislocation is most frequently caused by a fall on the outstretched hand. The bones assume an angle of flexion of about 120°. The bones are pulled upward by the triceps muscle. The articulating surface of the humerus can be plainly felt in front of the elbow. The posterior ligament does not suffer injury beyond stretching, and the periosteum, especially that over the external condyle (*epicondyle*) may be lifted, but the anterior and the two lateral (*collateral*) ligaments

are ruptured. The orbicular ligament (*annular ligament of the radius*) remains intact and keeps the radius in its normal relation to the ulna. The tendon of the biceps is pulled backward over the articulating surface of the humerus, and, though tense, is seldom ruptured. The brachialis will be forcibly stretched and occasionally torn near its insertion in front of the coronoid process. The ulnar nerve may be painfully stretched, on account of its being carried backward with the ulna; the median nerve, together with the ulnar and interosseous vessels suffers from the pressure of the projecting humerus.

Simple *forward dislocation* of the radius and ulna is rare, in fact many surgeons think it impossible. They contend that it is necessary to have a fracture of the olecranon process of the ulna in order to allow the bones to slip forward. The forearm is elongated on account of the added length of the olecranon process, which slips forward and rests in front of the trochlear surface of the humerus. There will be a depression in front, corresponding to the greater sigmoid cavity (*semilunar notch*) of the ulna. The trochlear surface of the humerus can be plainly felt posteriorly, with the tendon of the triceps tightly stretched over it, unless the tendon has been ruptured. The humeral condyles (*epicondyles*) are very prominent. The posterior ligament is ruptured and the lateral (*collateral*) ligaments are in extreme tension. When the dislocation is more nearly complete, the olecranon process of the ulna rests in front of the medial condyle (*epicondyle*) of the humerus, and the head of the radius in the coronoid depression of the humerus.

In both backward and forward luxations of the radius and ulna the olecranon process and the lateral and medial condyles (*epicondyles*) are not in line. The positive diagnosis of either of these dislocations depends upon the recognition of the position of the olecranon, the condyles (*epicondyles*), and the head of the radius.

The elbow-joint is most readily dislocated backward when the joint is in incomplete extension, for in this position the coronoid process offers less resistance to backward movement of the proximal end of the ulna, and the olecranon is not engaged in the olecranon fossa. Forward luxation is most likely to occur when the joint is incompletely flexed, as in this position the olecranon process of the ulna grasps the humerus less firmly, and the coronoid process is not engaged in the coronoid depression of the humerus.

Dislocations forward or backward are more common than lateral luxations. This is explained by the short anteroposterior and long transverse diameter of the joint and by the weakness of the anterior and posterior ligaments and the greater strength of the lateral (*collateral*) ligaments.

Medial luxation is always incomplete. This is probably due to the fact that the medial side of the trochlear surface of the humerus is somewhat elevated,

thus making it necessary for the ulna to ascend an inclined plane. This also accounts for the infrequent occurrence of this luxation. The median ridge of the greater sigmoid cavity (*semilunar notch*) of the ulna is forced over the inclined plane of the trochlea. The lateral part of the sigmoid cavity (*semilunar notch*) rests on the medial margin of the trochlea or below the medial condyle (*epicondyle*). The head of the radius is forced medialward and rests against the trochlear space, which is normally occupied by the sigmoid cavity (*semilunar notch*) of the ulna. The lateral condyle (*epicondyle*) becomes prominent while the medial is often confused with the olecranon. The ulnar nerve is forcibly stretched, and may cause intense suffering. The internal lateral (*ulnar collateral*) ligament is almost always ruptured, while the external lateral (*radial collateral*), the orbicular (*annular ligament of radius*), the anterior (*volar*), and the posterior ligament are put on the stretch.

Lateral luxation of both the **radius and ulna** is more frequent than medial luxation, on account of the inclined plane formed by the elevated ulnar side of the trochlear surface of the humerus. The dislocation is generally incomplete, although cases of complete lateral luxation of both bones have been recorded. In *partial* lateral dislocation the ulnar part of the sigmoid cavity (*semilunar notch*) rests on the capitellum (*capitulum*) of the humerus, or the crest of the sigmoid cavity (*semilunar notch*) occupies the depression between the trochlear surface and the radial head of the humerus. In *complete* lateral dislocation the coronoid process, the olecranon process, and the greater sigmoid cavity (*semilunar notch*) of the ulna can be plainly felt lying to the radial side of the humerus. The medial condyle (*epicondyle*) of the humerus is very prominent. The head of the radius, if the orbicular (*annular of radius*) ligament is intact, retains its normal relation to the ulna, but it may be carried forward or backward, if the ligament is ruptured. All of the ligaments of the elbow-joint are stretched, and some of them probably torn. The fibers of the brachialis and anconeus muscles may be lacerated. The tendons of the biceps and triceps brachii, though not injured, hold an abnormally oblique positon.

Dislocation of the **head of the radius** may be forward, forward and lateralward, or, rarely, backward.

In *forward luxation*, the most common luxation, the head of the radius is generally found upon the front of the humerus. The anterior and external lateral (*radial collateral*) ligaments are more or less torn, and the orbicular ligament (*annular ligament of radius*) is either lacerated or so stretched that it will allow complete luxation. The forward dislocation may result from roughly jerking a child's hand, or from lifting the child by the hand. The pull accompanied by hyperextension of the elbow and adduction of the hand draws the head of the radius from the orbicular ligament (*annular ligament of radius*), after which

the biceps pulls it anteriorly. In this manner the bones of the forearm may be fractured, the deltoid muscle torn, the shoulder dislocated, or the clavicle fractured.

In *backward luxation* both the orbicular ligament (*annular ligament of radius*) and the capsular ligament of the elbow are torn. The oblique ligament is either ruptured or stretched. The head of the radius is found rotating behind the lateral condyle (*epicondyle*).

Dislocation of the proximal end of the ulna alone is very infrequent. It is almost always associated with dislocation of the radius, or with fracture of one of the neighboring bony prominences. The anatomy is similar to that found in luxation of both bones, except that the orbicular ligament (*annular ligament of radius*) is always torn, while the head of the radius holds its normal relation to the capitellum (*capitulum*) of the humerus.

Dislocation of the radio-carpal joint is very rare, although simple luxation of the joint, either backward or forward, does occur and is sometimes complicated by fracture of the radius or the styloid process of the ulna. Dupuytren pointed out the fact that what were formerly treated as luxations of the wrist were really cases of fracture, usually of the radius.

In *backward luxation*, the more common of the two, the posterior and lateral (*collateral*) ligaments are torn, while the anterior ligament may remain intact, although it is often lacerated. The extensor muscles are apt to be torn from the bones in the distal part of the forearm, and also displaced. The nerves and arteries, in relation with the joint, are usually displaced or ruptured. The radius and ulna present anteriorly, while the first row of carpal bones lies behind the bones of the forearm and beneath the extensor tendons. If the luxation is compound, as it frequently is, laceration of the tendons which cross the joint takes place. The differentiation from Colles' fracture is important. In backward dislocation the palmar swelling extends further toward the hand, and is due to displacement occurring at the joint instead of above it, as in fracture; also in luxation the swelling on the back of the wrist is more abrupt than in fracture, and the styloid processes of both the radius and the ulna remain attached to the shafts of the bones.

If the carpus is *displaced forward*, the position of the various bones is reversed, the flexor tendons are lacerated and displaced, and the anterior ligament is ruptured. In both these types of luxation the forearm is shortened. In the backward luxation the hand is flexed, while in the forward it is extended. This luxation is occasionally seen in young people, occurring very slowly and without any demonstrable cause. It is then called Madelung's disease.

The **distal end of the ulna** may be dislocated either backward or forward, but this accident, uncomplicated by fracture of the radius, is rather rare. In *backward luxation* the posterior (*dorsal radio-ulnar*) and the internal lateral (*ulnar collateral*) ligaments of the wrist-joint are torn and the triangular fibrocartilage (*articular disc*) is detached from the ulna. The head of the ulna is forced out of its socket and lies across the distal end of the radius. *Forward dislocation* of the ulna is less common than backward luxation. The anterior radio-ulnar and the internal lateral (*ulnar collateral*) ligaments are torn, and the triangular fibrocartilage (*articular disc*) is detached from the ulna. The head of the ulna presents on the anterior surface of the radius.

The **separate carpal bones** are very seldom dislocated, on account of the strong surrounding tendons and firm ligaments. However, the author has twice seen the scaphoid dislocated. When any one bone of the carpus is luxated, the ligaments holding it in place are more or less stretched, according to the extent of the displacement, and the overlying or underlying tendons are somewhat displaced.

Luxation of the metacarpal bones of the fingers and thumb is very rare; in fact, it is doubtful whether it ever occurs except as a complication. These bones are so firmly held in place by the anterior annular (*transverse carpal*) ligament and their own ligaments, as well as by the flexor and extensor tendons that the accident is necessarily uncommon.

Dislocations of the phalanges are frequent occurrences, and often lead to permanent deformity.

Dislocation of the proximal phalanx of the thumb is not unusual and is often very difficult to reduce unless some of the interposed and resisting structures are divided. It may occur either as a backward or a forward luxation, the former being the more frequent.

In *backward luxation* the proximal end of the phalanx presents on the dorsum of the metacarpal bone of the thumb, and the head of the latter bone forms a distinct projection on the palmar surface of the thumb. The anterior ligament is torn and lies in front of or upon the head of the metacarpal bone; the lateral (*collateral*) ligaments may or may not be lacerated; the tendon of the flexor pollicis longus is displaced to the ulnar side of the head of the metacarpal bone. Many explanations have been offered for the difficulty in reducing this dislocation; some of them are that the neck of the metacarpal bone is held between the two tendons of the flexor pollicis brevis; that the neck of the metacarpal bone is held between the lateral (*collateral*) ligaments; that the muscles of the thumb are so strong that it is almost impossible to overcome them; but the interposition of the anterior ligament and other parts of the capsule between the articular ends

of the bones is regarded by many surgeons as offering the chief obstacle to reduction of this dislocation.

Forward luxation of the proximal phalanx of the thumb is not very common, and is more easily reduced than the backward variety. The base of the phalanx presents anteriorly, with the head of the metacarpal bone resting upon its dorsum. The lateral (*collateral*) and anterior ligaments may either sustain severe stretching or be torn.

In dislocation of the various phalanges of the fingers the lateral (*collateral*) ligaments are always stretched and may be torn; the anterior ligament may be lacerated, and the tendons passing to and over the bones displaced.

ANATOMY OF THE LONG BONES

Briefly considered, **the long bones,** such as the humerus, consist of a shaft and two extremities. The shaft is composed of an outer layer of hard, compact bone which covers a layer of cancellous bone tissue. The central portion of the shaft is occupied by the marrow which fills the medullary canal. This canal, or medullary cavity, extends towards but does not reach either extremity of the bone. The marrow, which in the long bones, is yellow in color. *Yellow marrow* is also found in the interspaces of the cancellous tissue. It is composed largely of fat cells together with marrow cells and retiform tissue. When a bone is fractured, some of the fat globules of the marrow may enter torn veins, held open by their adherence to the walls of the bony channels, and cause fat embolism. This theory is now almost obsolete. In the extremities of the bones the whole thickness of the bone internal to the compact bone is occupied by cancellous tissue arranged in such a manner as best to withstand stress and strain. The shaft receives its nourishment from the periosteum and from the nutrient artery which passes into the marrow, while the extremities are nourished by the periosteum and the articular arteries. When, in an amputation, a bone is divided above the point of entrance of the nutrient artery, the stump is nourished through the periosteum and the articular arteries.

The *periosteum* is a fibrous membrane which invests the bones at all parts, except where they are covered with articular cartilage, and gives attachment to large tendons. It carries the blood-vessels which nourish the external portion of the bone. In the adult it consists of a fibrous (outer) layer and a fibro-elastic (inner) layer. The cells next to the bone (osteoblasts) are concerned in the formation of new bone and this deeper portion is called the *osteogenetic*, or *cambium, layer* of the membrane, present during the active growth of the bone, and later becoming a part of the fibro-elastic portion of the periosteum. It is

from this layer that periosteal sarcomata originate. The outer layer of the periosteum is composed of fibrous connective tissue, arranged chiefly in a longitudinal direction. In raising flaps of periosteum it is well, on account of the longitudinal direction of the fibers, to make both longitudinal and transverse incisions into that membrane, so as to avoid splitting and stripping it from the bone for some distance.

The *growth of a bone* occurs in four ways: (1) by means of the osteogenetic layer of the periosteum; (2) through the epiphyseal cartilage; (3) through interstitial deposit or deposit by the osteoblasts in the Haversian systems, and (4) through the endosteum.

A *bone increases in thickness* chiefly through the osteogenetic layer of the periosteum and partly by interstitial deposit, and *in length* chiefly through the ossification of successively developed layers of cells of the epiphyseal cartilage which connects the shaft with the extremities, and to some extent by interstitial deposit. Therefore, in amputations through bones in young persons the periosteum should not be stripped back by pulling upon the flaps when the bone is divided, and in excisions of joints the epiphyseal cartilage should be left intact. As a result of disease or injury of the epiphyseal cartilage the epiphysis sometimes unites with the shaft, and the corresponding bone of the other side gradually becomes the longer of the two. Occasionally, after a slight trauma the osteogenetic layer of the periosteum becomes locally active, and an exostosis develops. In acute suppurative periostitis an early incision down to the bone is required to allow the pus to escape, for if drainage is not provided, the periosteum is floated from the shaft of the bone from one epiphyseal line to the other, and the whole shaft dies or undergoes necrosis. The incorporation of the periosteum with the ligaments at the line of attachment, and the free and separate supply of blood to the epiphyses through the articular arteries, fortunately minimize the danger of extension of the process into the joints, for involvement of the joints would probably necessitate amputation.

Development of the Bones of the Upper Extremity.—The time of union of the various centers of ossification in the bones of the body plays an important part in the diagnosis and treatment of the various types of fractures, especially when the fracture is located near one of the epiphyseal ends of the bone.

The **clavicle** is of interest because it is the first bone in the body to show signs of ossification. It has two centers of ossification: one for the shaft, and one for the sternal end. Ossification in the shaft begins about the sixth week of fetal life. At about the nineteenth year an epiphysis appears at the sternal end, and subsequently unites with the remainder of the bone; ossification is complete at about the twenty-fifth year.

The **scapula** has seven centers of ossification, the process starting at about the second month of fetal life: one for the body, two for the coracoid process, two for the acromion, one for the posterior border, and one for the inferior angle. At birth the body of the scapula is the only part which is ossified. The center for the superior and anterior part of the coracoid process appears in the first year. The other centers appear at about the fifteenth or sixteenth year, when the coracoid process joins the body of the bone. The acromion remains cartilaginous until the age of puberty. The two centers which then appear coalesce and unite with the spine at about the twenty-fifth year.

An **ununited epiphysis** of the acromion may be mistaken for an ununited fracture; the differentiation can be made by comparing the two sides. Ununited epiphysis is bilateral, whereas ununited fracture of the acromion is almost invariably unilateral.

The **humerus** has seven centers of ossification: one each for the shaft, the head, the greater tuberosity, the capitellum (*capitulum*), the medial condyle (*epicondyle*), the trochlea, the lateral condyle (*epicondyle*), and generally, one for the lesser tuberosity. At birth the shaft of the humerus is usually the only part of the bone ossified. Occasionally, there is an ossific center in the head of the humerus. These centers appear at different periods, and as a rule, unite in the reverse order of their appearance. At about the fifth year the centers for the head and the tuberosities coalesce; but the union of this epiphysis to the shaft does not take place until about the twenty-fifth year. The centers for the lateral condyle (*epicondyle*), capitellum (*capitulum*) and trochlea coalesce and unite with the shaft in the seventeenth year. The center for the medial condyle (*epicondyle*) forms a separate epiphysis, which joins the shaft during the eighteenth year. From this it can be seen that there may be separation of the proximal epiphyses as late as the twenty-fifth year, and of the distal ones as late as the sixteenth to the eighteenth year. The proximal end of the diaphysis is conical and is pointed in the center. The epiphysis fits over this like a cap, an arrangement which tends to prevent its displacement before union has occurred. It is well to remember that considerable shortening may follow epiphyseal separation in young children, because, owing to the injury, the bone may fail to increase in length.

The **radius** has three centers of ossification: one for the shaft which makes its appearance early in the second month of intra-uterine life, and one each for the two ends. The proximal end unites during the seventeenth, the distal during the nineteenth year.

The **ulna** has three centers: one for the shaft and coronoid process, which appears at about the second month of fetal life; one for the olecranon, and one for the distal end. The distal end unites to the shaft at about the eighteenth

year, and the olecranon center, although it does not begin ossification before the eighth, unites to the shaft at about the sixteenth year.

The **carpal bones** each have only one center of ossification; these appear after birth, at different periods.

The **metacarpal bones** have two centers. The metacarpal bones of the fingers have one for the shaft and the proximal end, and another for the distal end; the metacarpal bone of the thumb has a center for the shaft and the distal end, and another for the proximal end. These centers are united at about the twentieth year.

Each **phalanx** has two centers: one for the shaft and distal end, the other for the proximal end, which unite at about the twentieth year.

EXCISIONS

Excisions may be divided into excisions of bones and excisions of joints. Bones are usually excised for ununited fracture or for neoplasms, and joints for injury and disease or their results. Excision of a bone implies removal of either a portion or the entire bone. The injuries in which excision of a joint may be required are: fractures extending into joints, especially if compound; gunshot wounds of the joint or of the articular ends of the bones entering into the joint, and compound dislocations. Disease requiring excision is usually tuberculous. The operation is performed when more conservative measures fail. The operation also is often performed to save life, where the patient is becoming weaker as a result of pain and the persistence of the disease. One of the results of disease or injury to relieve which excision is performed is ankylosis of the joint in a bad position. In the upper extremity the best result is obtained by preserving mobility through the formation of a false joint. In the lower extremity ankylosis is more desirable than a false joint, as the latter cannot support the superimposed weight.

Conditions for which excisions are done in early life usually require amputation later on, especially if the disease involves a large joint.

In **excision of the clavicle,** an operation which is much more difficult in the living subject than on the cadaver, an incision is carried along the whole length of the bone, from its sternal to its acromial end. The incision should be carried down to the bone, so as to sever the skin, the superficial fascia and twigs from the acromio-thoracic (*thoraco-acromial*) and suprascapular (*transverse scapular*) arteries, the jugulo-cephalic vein, when present, the descending branches of the cervical plexus, and the platysma muscle. The periosteum should be divided the whole length of the bone, and stripped from it, first inferiorly and then superiorly. In stripping off the periosteum sever the attachments of the sterno-mastoid,

pectoralis major, trapezius, and deltoid muscles, and the attachment of the anterior layer of the costo-coracoid membrane. Next cut through the ligaments of the acromio-clavicular articulation, the superior and inferior acromio-clavicular ligaments, and the interarticular fibrocartilage (*articular disc*), then raise the acromial end of the bone and divide the structures attached to its under surface, namely, the coraco-clavicular ligament, the subclavius muscle with the posterior layer of the costo-coracoid membrane, and the rhomboid (*costo-clavicular*) ligament. Next detach the bone from the opposite clavicle and sternum by dividing the interclavicular ligament, the anterior and posterior sterno-clavicular ligaments, and the interarticular fibrocartilage (*articular disc*). In this locality care must be taken not to injure the internal mammary artery. In separating the clavicle from the underlying structures care must also be taken to avoid injuring the subclavian vessels and the brachial plexus.

In sarcomata of the clavicle the presence of many additional vessels makes the excision more difficult. If the subclavius muscle has remained intact, it may be taken as a guide to the subclavian vessels which lie beneath it.

Excision of the shoulder-joint is required for disease of the joint, and caries of the head of the humerus. Since the glenoid cavity quickly recovers after the head of the bone is excised, the glenoid fossa need not be removed. Excision may also be necessary in the treatment of injuries, such as compound fractures and gunshot wounds, and sometimes the results of injury or disease may require excision of the head of the humerus. Ankylosis of this joint seldom demands excision, because the weight of the arm causes fixation in the best position—with the arm at the side—and the mobility of the scapula largely compensates for fixation in the shoulder-joint; furthermore, the utility of the limb after excision may not be any greater than after ankylosis has taken place.

Excision of the head of the humerus.—In excision of the head of the humerus an incision is carried from just lateral to the coracoid process ten or twelve centimeters (four or five inches) distally toward the middle of the lateral side of the humerus, to the deltoid insertion. The incision is not in the groove between the deltoid and pectoralis major, but goes through the anterior fibers of the deltoid. The incision should be made down to the bone, dividing in its course the skin, the superficial fascia, twigs from the acromio-thoracic (*thoraco-acromial*), anterior and posterior circumflex vessels, the acromial branches of the cervical plexus of nerves, the deep fascia, the anterior fibers of the deltoid muscle, and the trunks of the anterior circumflex artery and vein. The capsular ligament is opened along the lateral edge of the long tendon of the biceps and the supraspinatus, infraspinatus, and teres minor muscles severed from their attachment to the greater tuberosity, and the subscapularis from the lesser tuberosity after rotating

the arm lateralward and displacing the biceps tendon medialward. These muscles should be detached close to their insertions into the tuberosities. The coraco-humeral and capsular ligaments are then divided and the head of the humerus protruded from the glenoid cavity by carrying the arm in front of the body and pushing it upward. The diseased portion of the bone can then be removed without injury to the posterior circumflex vessels, the circumflex (*axillary*) nerve, and the structures in the axilla. At times it may be necessary to detach the head of the bone from the shaft while it remains in the glenoid cavity. In such cases a broad strip of metal should be passed between the neck of the bone and the axillary structures, in order to prevent injury to the latter.

Excision in the continuity of the humerus.—In excising a portion of the shaft of the humerus the incision, if possible, should be made on the lateral aspect of the arm, in the sulcus between the biceps in front and the triceps behind. The skin, the superficial fascia, twigs of the upper and lower cutaneous branches of the circumflex (*axillary*) nerve, twigs from the anterior and posterior circumflex and superior profunda (*profunda brachii*) vessels, the deep fascia, and the periosteum will be severed, but the cephalic vein should be avoided. The incision should be made as long as necessary, and in carrying it distally care should be taken to keep close to the lateroposterior border of the deltoid and the lateral border of the biceps. In the distal third of the arm it is necessary to avoid the musculo-spiral (*radial*) nerve, which lies between the brachialis and supinator longus (*brachio-radialis*) muscles in order to prevent post-operative extensor paralysis. The periosteum should be separated from the bone, and as much as necessary of the humerus removed. There will be but little bleeding.

Excision of the elbow-joint is performed for disease of the joint, such as tuberculous arthritis; for injury, compound dislocation, compound and comminuted fractures, and for the results of disease, such as ankylosis in a bad position. One of two results are obtainable by this operation, a movable joint or ankylosis in flexion at an angle of 135°. Ankylosis of this joint causes considerable disability; therefore, in treating disease of the joint it is most important to preserve its mobility.

With the forearm pronated and slightly flexed, a longitudinal incision about ten centimeters (four inches) in length is carried over the posterior surface of the joint, the middle of the incision being directly over the olecranon process of the ulna. The incision severs the skin, superficial fascia, and deep fascia, bisects the triceps tendon and passes down to the bone. The joint is opened in the same line and the parts retracted. The lateral half of the triceps, its aponeurotic expansion, and the anconeus muscle with the periosteum should then be carefully pushed to one side and next the medial part of the triceps lifted. By keeping the

elevator close to the bone, the periosteum with the attached muscles and ligaments may be lifted away from the bone and the ulnar nerve, which lies in the groove between the medial condyle (*epicondyle*) of the humerus and the olecranon will not be injured. The joint is flexed acutely, so that the distal end of the humerus protrudes. This is stripped of muscular attachments as high as the condyles (*epicondyles*) and the bone sawed through transversely just below the tips of the condyles (*epicondyles*). The proximal ends of the radius and ulna are now stripped, care being taken on the lateral side to avoid the dorsal interosseous nerve. The ulna is sawed off transversely, leaving as much of the coronoid as possible. The radius is sawed off through its neck, thus allowing the brachialis and biceps muscles to remain intact.

Since after operation for disease, ankylosis is likely to occur, the amount of bone removed must not be too small, and passive motion should be practised after about ten days. After excision for injury a flail-like joint is more likely to result than ankylosis; the part, therefore, must be kept steady by a splint, which should have a hinge at the elbow so that passive motion may be practised without allowing lateral movement of the joint. Passive motion should at first consist merely of a change in the position of the forearm, which should be flexed during the day and extended at night. Later, more extensive movements may be more frequently and freely performed and supination and pronation practised.

Excision of the bones of the forearm.—For **complete or partial excision of the ulna,** the incision should be carried along the dorsal or subcutaneous border of the bone, between the extensor carpi ulnaris and the flexor carpi ulnaris. The skin, superficial fascia, a few small vessels and nerves, and, generally, the posterior branch of the internal cutaneous (*ulnar branch of medial cutaneous nerve of forearm*) nerve will be severed. Subperisoteal resection should be employed whenever possible. Removal is facilitated if the bone is divided and removed in two pieces. At the distal end of the ulna care should be taken to avoid the dorsal branch of the ulnar nerve.

For complete or partial excision of the radius, the incision should be made laterally along the side of the bone, between the supinator longus (*brachio-radialis*) and the extensor carpi radialis longus below, and between the supinator longus (*brachio-radialis*) and the two radial carpal extensors above, taking advantage of the position of the radial nerve in locating the interval between the tendons of the respective muscles. The skin, the superficial fascia, a few small vessels and nerves, the deep fascia, and the periosteum will be severed. The periosteum is separated from the radius as far as necessary; the insertion of the supinator longus (*brachio-radialis*) at the distal end of the bone and that of the pronator teres at the middle of the bone being detached with the periosteum. Above, the

supinator brevis (*supinator*) must be divided longitudinally to expose the bone. The bone is then divided and removed.

Excision of the radio-carpal joint.—Excision of the wrist-joint is usually performed for disease, such as caries, and occasionally, for injury, such as compound fracture, compound dislocation, or a gunshot wound. If excision is performed for disease, it is usually necessary to remove the ends of the radius and ulna, the carpus, and the bases of the metacarpal bones, so as to include all the diseased bone. Interference with the sheaths of the tendons will result in stiffness, loss of control and power of the hand. Passive motion of the fingers must be practised early to obtain the best possible result. The surgeon should not routinely do a typical operation, but should preserve any bones which are free from disease. This is especially true in connection with the trapezium (*multangulum majus*) with which the metacarpal of the thumb articulates. In excising the wrist-joint two incisions should be made: one along the radius, extending from a point about five centimeters (two inches) above the styloid process of the radius to the lateral side of the middle of the second metacarpal bone; and another along the ulna, from a point about five centimeters (two inches) above the styloid process of the ulna to the base of the metacarpal bone of the little finger. In making the *radial incision* care must be taken not to injure the radial artery which lies in front of the distal end of the radius and upon the external lateral (*radial collateral*) ligament of the wrist-joint. The radial incision passes between the tendons of the extensor ossis metacarpi pollicis (*abductor pollicis longus*) and extensor primi internodii pollicis (*extensor pollicis brevis*). The *ulnar incision* passes laterally along the extensor carpi ulnaris tendon. Care should be taken to avoid the dorsal branch of the ulnar nerve to the little finger. The tendons and soft parts should be carefully dissected from the posterior surface of the carpus, radius, and ulna. The lateral (*collateral*) ligaments are divided, the ulna and radius drawn out on their respective sides, the periosteum and soft parts elevated, and the articulating surfaces removed. Divide the dorsal ligaments between the two rows of carpal bones, and remove the proximal row. The removal of the carpus is difficult, tedious and often inefficient. If necessary, all the bones of the carpus may be removed in this manner. Care must be taken in removing the unciform (*hamatum*) not to injure the deep branch of the ulnar nerve and in removing the trapezium (*multangulum majus*) to avoid wounding the radial artery. As the carpo-metacarpal articulations are reached, great care must be taken not to injure the deep palmar (*deep volar*) arch. With proper care there is little danger of wounding the radial and ulnar arteries.

In **excising a metacarpal bone** the incision should be made over the dorsal aspect of the bone. The incision involves the skin and fascia, the tendons and

sheaths being retracted. The periosteum is divided, and if the head of the bone is to be removed, the metacarpo-phalangeal joint must be opened by cutting through one of the lateral expansions of the extensor tendon, raising the tendon, and dividing the lateral (*collateral*) ligaments and the transverse metacarpal ligament. The results are not so good when the metacarpo-phalangeal joints are destroyed. The bone is then elevated. The interosseous muscles must be separated from the bone with the periosteum, and the bone freed from all surrounding structures. As much of the metacarpal bone as is diseased can then be removed. Care must be taken not to injure the deep palmar (*deep volar*) arch when removing the structures from the palmar surface of the bone. If the entire bone is to be removed, the carpo-metacarpal ligaments must be severed. Traction in the long axis of the finger is maintained to prevent retraction.

In **excision of the metacarpal bone of the thumb** the incision should be made on the line between the dorsal and palmar surfaces. Skin, fasciæ, branches of the radial artery, superficial veins, and branches of the radial nerve will be severed, but with care the branch of the radial nerve supplying the lateral side of the thumb need not be divided. The incision reaches the bone by passing along the palmar side of the tendon of the extensor primi internodii pollicis (*extensor pollicis brevis*). The soft structures with the periosteum are separated from the bone on the palmar and dorsal surfaces, and the ligaments of the carpo-metacarpal and metacarpo-phalangeal joints severed.

In **excising the articulating surfaces of the phalanges** the incision should be made over the dorsal aspect of the respective joints at the side of the extensor tendon, and should extend from the proximal side of the joint to the middle of the phalanx to be removed. The incision is made parallel with the extensor tendon, which is pushed to one side as soon as it has been exposed. The extensor tendon is raised, the lateral (*collateral*) ligaments are severed, the ends of the bones are elevated, and as much bone as necessary removed with the bone forceps.

In **excising the distal phalanx** the incision may be made either along the palmar surface of the finger, or around the end of the finger close to the nail in the shape of an U. In the former, the soft parts are stripped from the sides of the bone, and in the latter from the dorsal and palmar aspects. The bone is then grasped with the bone forceps and twisted on its long axis so as to facilitate the division of the two lateral (*collateral*) ligaments and of the flexor and extensor tendons. It is better to leave the soft parts in place than to remove part of them with the bone; also, if the base of the phalanx is not much diseased, it is better not to remove it, on account of the attachment of the tendons.

FRACTURES

The treatment of fractures aims: (1) to return the parts to their normal relations; (2) to immobilize the fragments in correct alignment by means of a splint, which extends throughout the length of the fragments and beyond the joints moved by muscles attached to the fragments; (3) to restore the function of joints or tendons in close proximity by passive movement practised as soon as union is sufficiently firm.

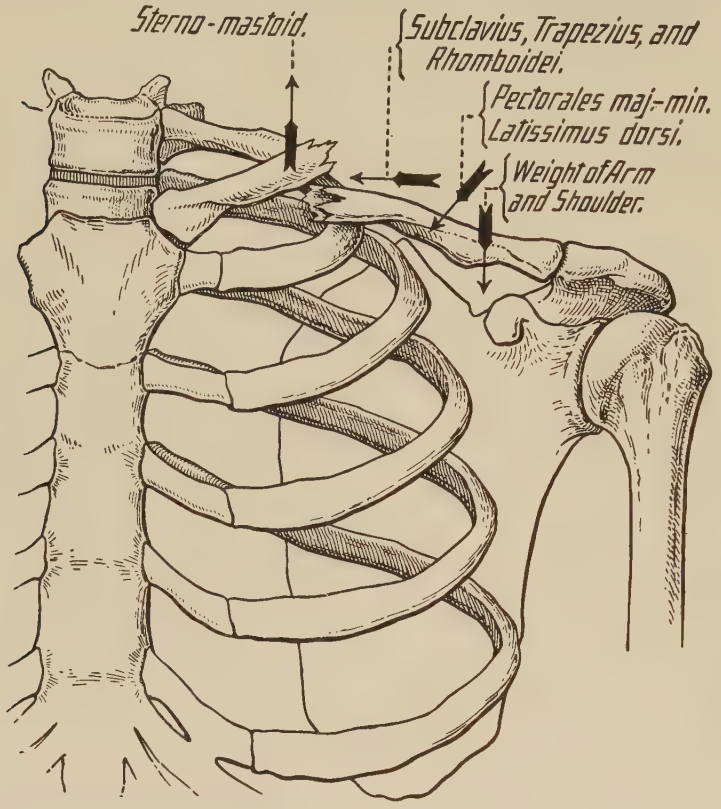
Fracture of the clavicle (Plate CLXXXVII) is very frequent because the bone holds an exposed position and is the only bony connection between the upper extremity and the trunk. This bone and the radius have the distinction of being the most frequently fractured bones of the body. As about one-half of these fractures occur in children under five years of age, "greenstick" fracture of this bone is common. In this there may be little displacement, and the true condition may not be detected until callus forms and a swelling is produced. If a child has fallen and cries constantly, the clavicle should be carefully examined.

In comminuted fracture of the clavicle there is danger that the subclavian vein, subclavian artery, or the brachial plexus may be injured, although, owing to the protection afforded by the intervening subclavius muscle and prevertebral fascia, these complications are rare. If the vein or the artery is torn, the blood gravitates to the axilla through its apex. Injury of the brachial plexus leads to motor and sensory disturbances in the upper extremity. Of the three structures the vein is most likely to be injured because of its closer relation to the bone and the thinness of its walls.

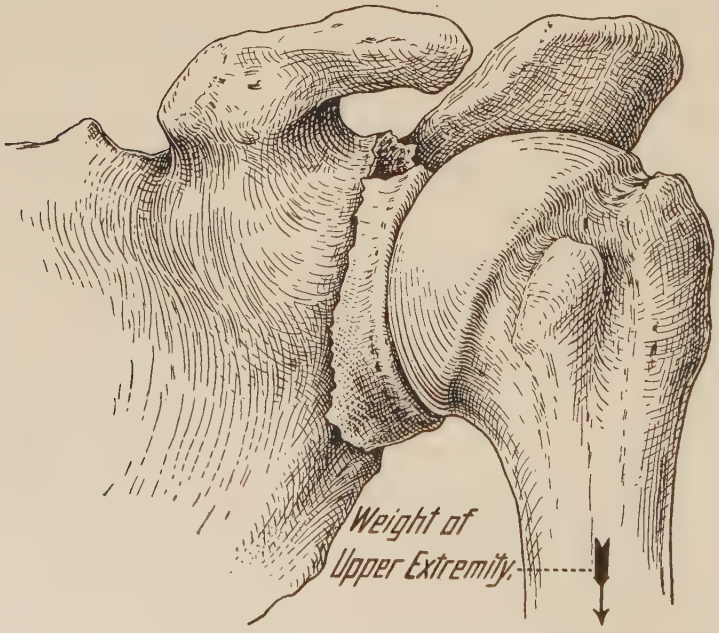
Fracture of the clavicle generally occurs near the lateral end of the middle third, because the bone at this situation is smaller and consequently weaker, has less support from the muscles and ligaments, and, because it is here that the anterior passes into the posterior curve. The deformity resulting from fracture of the middle third of the clavicle is displacement of the medial fragment upward, and of the lateral fragment downward and medialward. The medial fragment is drawn upward by the sterno-mastoid. The lateral fragment is drawn downward by the weight of the arm and shoulder; downward and medialward by the pectoralis major, the pectoralis minor, and the latissimus dorsi; medialward by the subclavius, trapezius, and rhomboidei muscles.

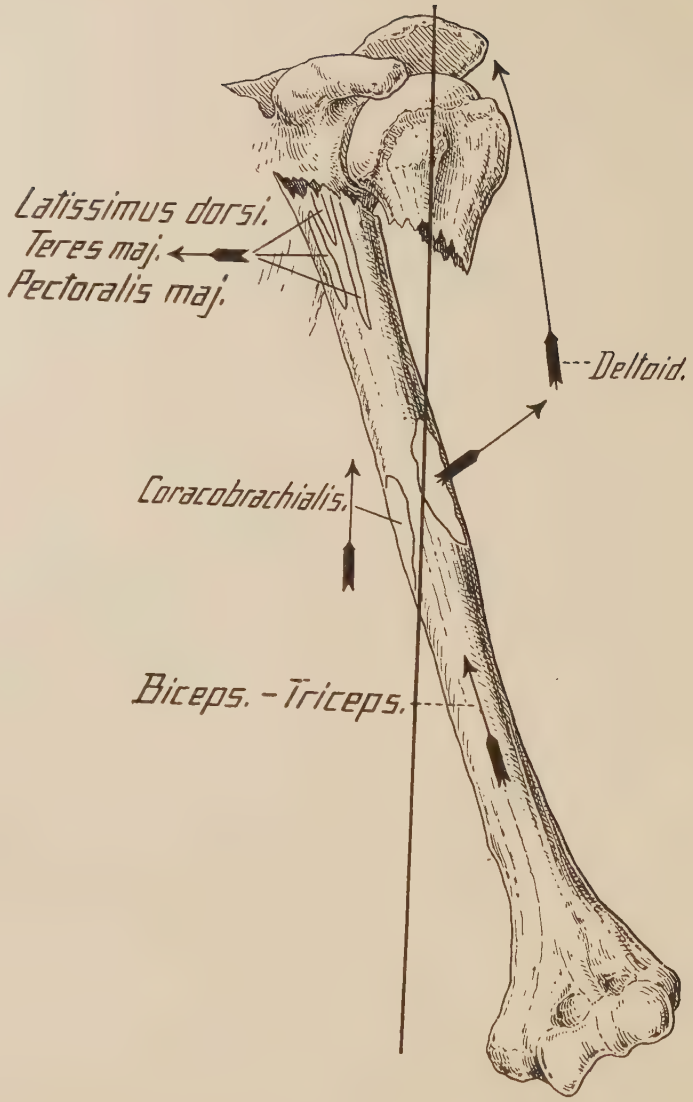
In displacement of the medial fragment upward the action of the sterno-mastoid is antagonized by the rhomboid (*costo-clavicular*) ligament, the clavicular portion of the pectoralis major, and the medial fibers of the subclavius muscle.

Displacement in Fracture of the Middle of the Clavicle.

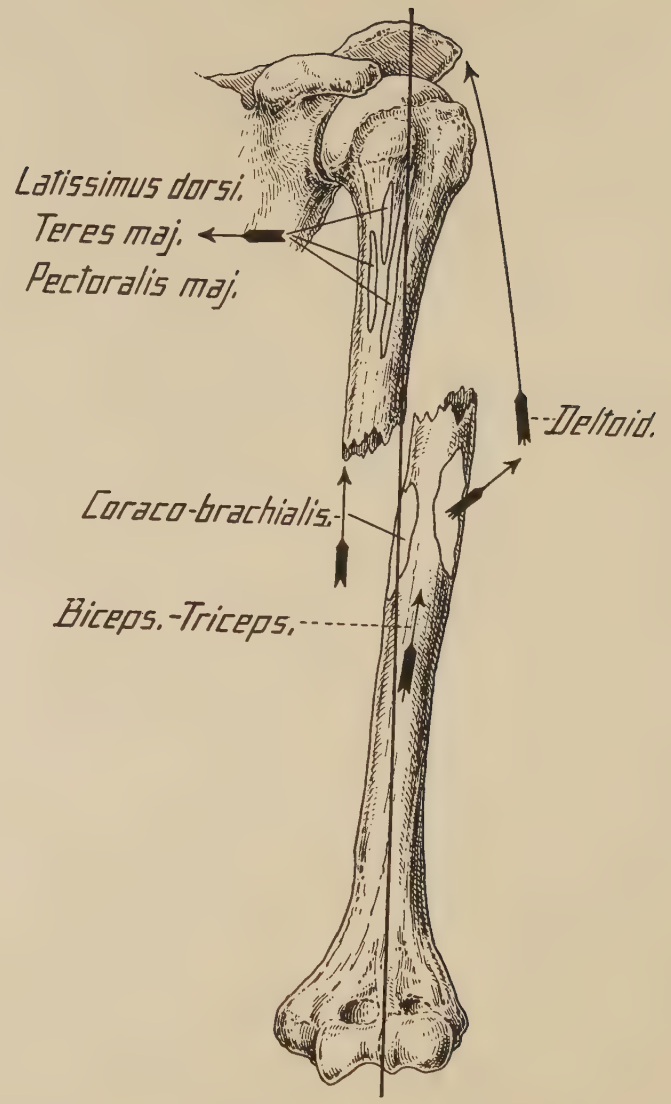


Fracture of Anatomic Neck of Scapula.

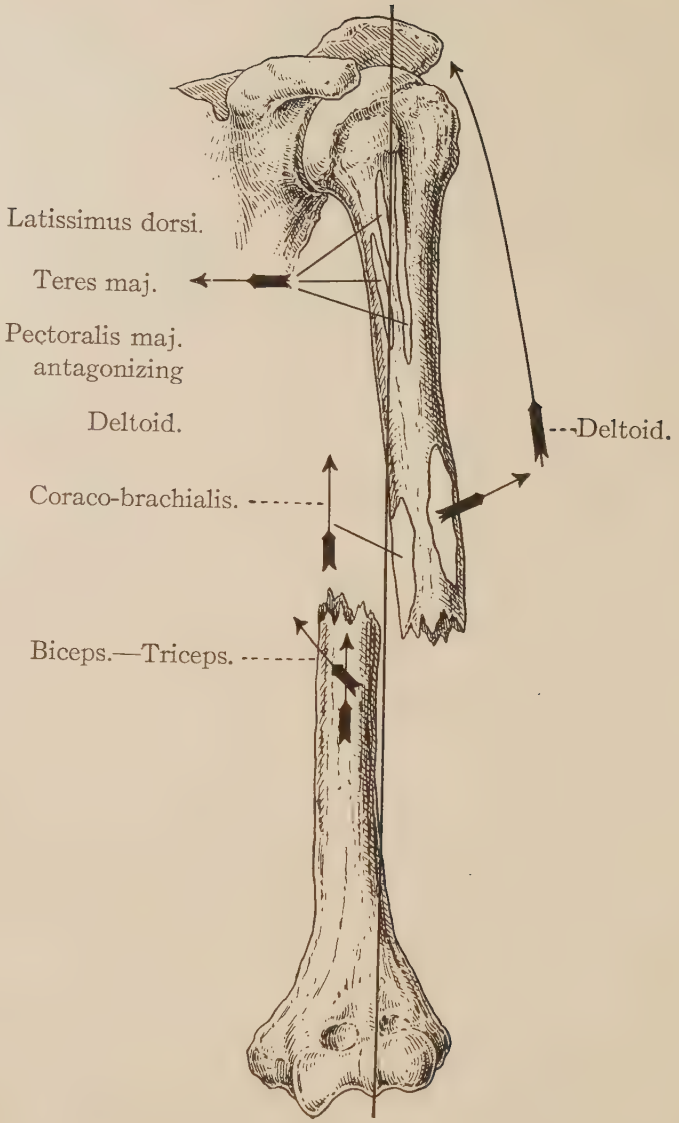




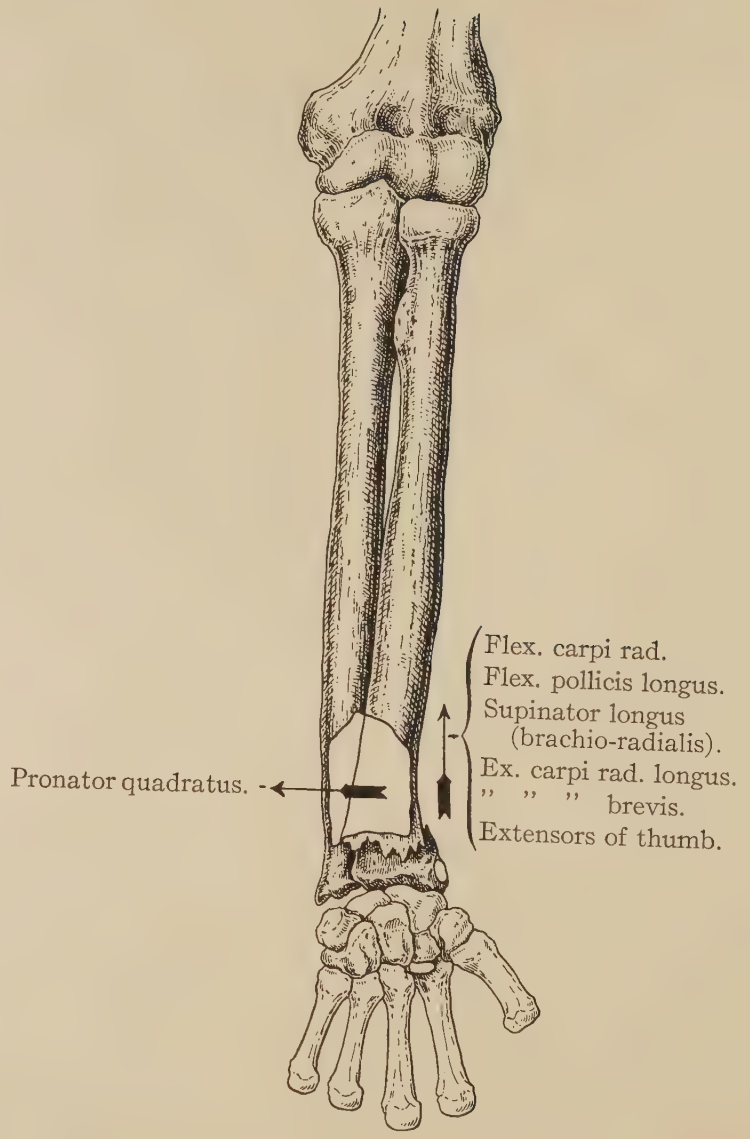
FRACTURE THROUGH SURGICAL NECK OF HUMERUS.



FRACTURE ABOVE INSERTION OF DELTOID MUSCLE.



FRACTURE BELOW INSERTION OF DELTOID MUSCLE.



COLLES' FRACTURE.

The clavicular fibers of the trapezius antagonize the downward displacement of the lateral fragment, and the serratus magnus (*serratus anterior*), its displacement medialward.

Fractures of the scapula are uncommon, only one per cent of all fractures occurring in this bone. This is due to the free mobility of the bone and to its protection by overlying muscles. Fractures may involve any portion of the bone. Although usually produced by direct violence, they may also be caused by muscular strain or by indirect violence, as a fall upon the arm. Fractures of the *body* of the scapula not involving the spine of the bone are not easily detected, because of the thickness of the overlying muscles; whereas, those of the spine and acromion are readily apparent because of their superficial position. Fracture of the *anatomic neck of the scapula* (Plate CLXXXVII), which is lateral to the coracoid process, is very rare. This condition simulates subglenoid dislocation, in that the arm is lengthened as the arm and the glenoid cavity drop downward; it can be readily differentiated by raising the arm, when crepitus may perhaps be elicited. As soon as support of the arm is withdrawn, the arm again lengthens. In fracture of the anatomic neck of the scapula, injury of, or pressure upon the axillary vessels and brachial plexus is almost certain to occur. In fracture of the *surgical neck of the scapula* the glenoid cavity and arm are prevented from dropping downward by the attachment of the coracoid process to the clavicle by the coracoacromial and coraco-clavicular ligaments, as well as by the inferior transverse ligament, unless these are torn. Fractures of the *spine* and the *acromion* are detected by tracing these subcutaneous processes with the finger. Most of the recorded fractures of the acromion are thought to have been ununited epiphyses. Fracture of the *coracoid process* is produced by indirect violence applied to the arm, thereby forcing the scapula upward and driving the coracoid process against the clavicle. This fracture is very rare.

Fractures of the humerus (Plates CLXXXVIII; CLXXXIX) comprise about eight per cent of all fractures. They may occur through any of the various divisions of the bone, as the anatomic neck, the tuberosities, the surgical neck, the shaft, the lateral or the medial condyle (*epicondyle*), the shaft immediately above the condyles (*epicondyles*), and between the condyles (*epicondyles*). Separation of the epiphysis may occur at either extremity of the bone.

In fracture of the *anatomic neck*, which is usually due to direct violence and almost always, though not invariably, occurs in old people, the displacement may be medialward and anteriorly or there may be very little displacement. The break is largely within the capsule of the joint. As such fractures are usually due to indirect violence, the head of the bone may be forced into the cancellous tissue of the lower fragment and an impacted fracture result.

In fracture through the *greater tuberosity* the anteroposterior diameter of the shoulder-joint is increased, and a sulcus created between the front of the joint and the fragment. The rotundity of the shoulder is altered but not lost. The fragment is drawn upward and backward by the action of the supraspinatus, infraspinatus, and teres minor muscles, which are inserted into the greater tuberosity. Fractures which cause detachment of the tuberosities are often accompanied by luxation. The subsequent disability is often great and the prognosis is not favorable.

In fracture of the *surgical neck*, which is the most common fracture of the humerus, the line of the break is below the tuberosities, and above the insertion of the teres major and latissimus dorsi. The proximal fragment is abducted and rotated lateralward by the action of the muscles attached to the greater tuberosity, especially the supraspinatus. The distal fragment is drawn upward toward the axilla by the biceps and triceps, the coraco-brachialis, and the deltoid muscles; medialward by the pectoralis major, teres major, and latissimus dorsi muscles, and somewhat anteriorly by the pectoralis major. Marked displacement of the distal fragment is prevented by the long head of the biceps in front and the long head of the triceps behind.

In persons under twenty years of age separation of the *epiphysis* is more likely to occur than actual fracture of the surgical neck of the humerus, and, as the length of the bone is chiefly derived through growth of this upper epiphyseal cartilage, considerable shortening may ultimately result (from injury to the epiphysis). The epiphysis is a short distance above the line of the surgical neck.

In fractures of the *shaft* of the humerus the displacement will depend upon the location of the fracture. If above the insertion of the deltoid and below the insertion of the pectoralis major, the proximal fragment will be drawn medialward by the latter muscle as well as by the teres major and latissimus dorsi; the distal fragment will be drawn directly upward and lateral to the proximal fragment by the action of the deltoid, and, indirectly, by the biceps and triceps and the coraco-brachialis muscles. It is because of the pull of the deltoid that the abducted position is used in dressing these fractures. If the fracture is immediately below the insertion of the deltoid, the position of the proximal fragment is little altered by muscular action, as the deltoid is antagonized by the pectoralis major, latissimus dorsi, teres major, and coraco-brachialis. On account of the usual downward and lateral direction of the line of fracture, the distal fragment is found on the medial side of the proximal fragment, being drawn upward by the biceps and triceps muscles.

When the distal part of the shaft of the humerus is broken, the displacement is slight, because of the broad attachment of the brachialis in front and the counterbalancing influence of the triceps behind.

In *supracondyloid* fracture, which is the most frequent fracture at the distal end of the humerus, the displacement is similar to that of a backward dislocation of both bones of the forearm. The line of fracture runs transversely just above the condyles (*epicondyles*), obliquely downward and foward. The proximal fragment overrides the distal, and the latter is displaced backward by the action of the brachialis and the biceps, and upward by the biceps and triceps. The brachialis and the biceps, by flexing the elbow-joint, tilt the distal fragment backward.

In *intercondyloid* fracture the deformity consists of a widening of the joint.

Fractures of the *condyles* (*epicondyles*) may or may not be associated with an intercondyloid, or T fracture. The main deformity is a widening of the elbow-joint, with downward displacement of the condyle (*epicondyle*).

Fracture of the condyles (*epicondyles*) is frequently followed by medial deflection of the bones of the forearm at the elbow. In the normal condition, with the forearm extended and supinated, the radius and ulna form an obtuse angle with the humerus, so that when the arm lies at the side of the body, the hand projects away from the median line. By an upward displacement of the medial condyle (*epicondyle*), or a downward of the lateral, this angle may be lost, resulting in the so-called gun-stock deformity (*cubitus varus*), described by Allis. It is of the greatest importance to preserve the carrying angle in these fractures if a good functional result is to be obtained.

In fractures of the proximal end of the humerus, the surgical or anatomic neck, the circumflex (*axillary*) nerve may be injured, in fracture of the shaft the musculo-spiral (*radial*) nerve, and in fracture of the medial condyle (*epicondyle*) the ulnar nerve. When the symptoms of nerve injury appear shortly after or at the time of the occurrence of the fracture, they are due to laceration or to pressure by a fragment; but if they develop late, they are the result of pressure by callus, the character of the symptoms depending upon the degree of pressure. Moderate pressure irritates the nerve, and causes tingling and pain in the area of distribution of its sensory branches, and spasm of the muscles supplied by its motor branches. Greater pressure causes anesthesia and trophic disturbances in the area supplied by its sensory fibers, as well as paralysis and atrophy of the muscles supplied by its motor branches. However, the circumflex (*axillary*) nerve is rarely injured in fractures, although injury to the musculo-spiral (*radial*) and ulnar nerves occasionally occurs. When the circumflex (*axillary*) nerve is involved, there is pain or partial or complete anesthesia over the deltoid and proximal part of the triceps, and spasm or paralysis of the deltoid and teres minor; involvement of the musculo-spiral (*radial*) nerve causes pain or more or less anesthesia in the dorsolateral part of the arm and forearm, and spasm or paralysis of the muscles which the nerve supplies. These muscles are the triceps, the

anconeus, supinator longus (*brachio-radialis*), extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis, extensor minimi digiti (*extensor digiti quinti proprius*), extensor carpi ulnaris, supinator brevis (*supinator*), extensor ossis metacarpi pollicis (*abductor pollicis longus*), extensor pollicis longus, extensor pollicis brevis, and extensor indicis proprius. Paralysis of the triceps is unusual because of the high origin of the branches to that muscle. The condition which results from paralysis of the musculo-spiral (*radial*) nerve is known as "wrist drop." The hand is pronated and the wrist and fingers are flexed. Loss of opposition from the extensors, which steady the fingers during flexion, causes loss of power in grasping objects.

When the ulnar nerve is affected, there is, according to the degree of involvement, pain or anesthesia in the ulnar side of the forearm and hand, in the little finger and ulnar half of the ring finger, together with spasm or paralysis of the flexor carpi ulnaris, the ulnar side of the flexor digitorum profundus, the palmaris brevis, the short muscles of the little finger, the two ulnar lumbricales and interossei, the adductor pollicis, and the median head of the flexor pollicis brevis. Paralysis of the interossei affects the equilibrium between the flexors and extensors, and as a result the proximal phalanges are extended and the distal phalanges partially flexed. This produces a "*clawed hand*," or "*main en griffe*." Power of flexion of the little and ring fingers is lost, and movement of the thumb is much diminished.

Fracture of the radius occurs much more frequently in its distal third than in its middle or in its proximal third.

In fracture of the *head* or of the *neck* of the radius the distal fragment is carried upward and forward by the biceps which is inserted into the tuberosity. Although many surgeons and anatomists claim that it is impossible to have a fracture of the neck of the radius unless it is complicated by some other fracture or a dislocation, the author has proved by X-ray studies and subsequent operation that simple fracture of the neck of the radius does occur.

Fracture of the radius may occur between the insertions of the biceps and the pronator teres, although such a fracture is very rare. The proximal fragment would be strongly supinated by the action of the biceps and the supinator brevis (*supinator*), and the distal would be pronated and approximated toward the ulna by the pronator teres and the pronator quadratus. As the two strong supinators, the biceps and supinator brevis (*supinator*), would have no influence over the distal fragment, the supinator longus (*brachio-radialis*) could not counterbalance the action of the pronator teres and pronator quadratus. Fractures of the shaft of the radius must be treated with the hand in full supination or in the midposition, depending upon whether they are above or below the insertion of the

pronator teres muscle, because in these positions the interosseous space is best preserved.

Fracture of the *distal end* of the radius (**Colles' fracture**) (Plate CLXXXIX) is the most frequent one of this bone. The fracture occurs at from one to three centimeters (one half to one and a half inches) above the wrist, and passes transversely across the bone or inclines slightly downward to the ulnar side and backward toward the elbow. The deformity is chiefly caused by the breaking force, which pushes the distal fragment backward and upward, making it override the proximal fragment, which is forced downward and forward. The alteration of contour thus effected is known as the "silver-fork deformity" of Velpeau. The displacement of the fragments upward and backward is partly due to the extensors of the wrist and fingers, and partly to the direction of the violence. The hand is carried to the radial side by the supinator longus (*brachio-radialis*), the extensores carpi radialis longus and brevis, and the extensors of the thumb, which are rendered tense by the displacement of the distal fragment.

Fracture of the ulna may occur at any point. As a rule, it is caused by direct violence, and for this reason there is no uniform displacement of the fragments, since it must vary with the angle of impact at which the fracturing force operates. The more usual direction, if any, for such displacement is probably for the distal fragment to be drawn toward the radius by the action of the pronator quadratus. The proximal fragment can only be displaced to any extent backward or forward, because of its connection with the humerus at the elbow-joint.

In fracture of the *olecranon process* the displacement of the proximal fragment is always upward, and is determined by the action of the triceps. The extent of displacement depends upon the power of the fracturing force and the extent of rupture of the ligaments which surround the elbow-joint, especially the degree to which the fibrous expansion from the triceps to the lateral condyle (*epicondyle*) and the proximal fourth of the ulna is torn. If, when the fracture occurs the forearm happens to be markedly flexed, the ulna will probably be dislocated forward by the action of the biceps and the brachialis.

Fracture of the *coronoid process* is exceedingly rare. If it should occur, the process will probably be drawn upward by the brachialis, which is attached to its base. As the coronoid process forms the anterior wall of the greater sigmoid cavity (*semilunar notch*) of the ulna, this fracture is usually associated with a backward dislocation of either this bone alone or of both the radius and ulna.

Fracture of both bones of the forearm most commonly occurs in the middle or in the distal third where there is least protection by muscles. When the fracture is complete, the deformity is usually very slight, but if incomplete, or of the

"greenstick," type, the deformity depends upon the degree to which the bones are bent. Occasionally, there is sufficient displacement to produce an angular deformity. The preservation of the interosseous space is of prime importance.

Simple fractures of the carpus are rare. They lead to little, if any, displacement of the fragments, owing to the firm ligamentous connections existing between the bones.

In **fractures of the metacarpal bones** there is but little displacement, on account of the attachments of the ligaments and the position of the flexor and extensor tendons and interossei muscles, all of which tend to hold the fragments in place. Whatever displacement there is, causes the proximal end of the distal fragment to project on the back of the hand, resulting in shortening, produced by the fracturing force and by the action of the flexors and extensors.

In **fractures of the phalanges** there is also little displacement. It is usually transverse, due to the direction of the breaking force. If the line of fracture is oblique, there may be some overlapping.

AMPUTATIONS

In amputations the following considerations should be borne in mind: (1) save the patient's life; (2) obtain a useful, weight-bearing stump; (3) secure a sufficient and healthy cutaneous covering for the end of the stump, with a minimum of redundant muscular tissue. All tendons should be cut even with the end of the bone, or bones, and not drawn out, as it is desirable to have them adhere to the cicatricial tissue and add to the mobility of the stump. Large nerves should be gently drawn out and severed as high as possible, so that they will retract within their sheaths and the bulbs, or false neuromata, which form upon their cut ends, will not be included in the cicatrix and cause a painful stump. It is often advisable to inject the end of the nerve with absolute alcohol to cause still further destruction. (4) The flaps should be made preferably by dissection, and be of sufficient length to avoid the formation of a conical stump and to allow free mobility of the stump. (5) The resulting scar should not be in the middle of the end of the stump, because pressure upon the scar causes pain, and thus lessens the usefulness of the member. In the thigh and leg it should be situated posteriorly; this can be secured by making a long anterior and a short posterior flap. In this location the greater contraction of the muscles divided upon the dorsal aspect tends to retract the scar still further posteriorly. At the wrist or ankle or in the foot, a palmar or plantar flap is desirable, as it is best adapted for bearing pressure. (6) It is well to save as much of the limb as can be retained with safety and for future utility, as the higher the amputation, the greater the danger of the operation. But it is also necessary to bear in mind that the brace maker in

America uses bony prominences for weight bearing, and it is therefore important to consult him if possible as to the site where he can adjust an artificial limb to the best advantage. (7) A deformed and ugly living appendage is likely to be of greater utility than the best artificial one.

After the operation is completed, the vessels are ligated, the wound is cleansed, drainage established, and the flaps held in apposition by sutures.

Amputations are performed at one of two points: through the continuity of the limb or in contiguity through a joint, in reality disarticulation.

Amputations are performed by one of a number of methods. The most common methods are:

The circular method.—In the original circular method the bone and all other tissues were divided at the same level. This is at present known as the guillotine amputation. In the more modern method three incisions are made. The first divides the skin and superficial fascia and separates the superficial from the deep fascia, thus a cuff of skin and superficial fascia, the length of which equals one-half the diameter of the limb, is dissected up, everted, and rolled as high as possible. The second incision divides the deep fascia and underlying tissues at the level of the attachment of the cuff of skin and superficial fascia; the third divides the bone as high as possible, while the soft tissues are retracted. The resulting wound is in the form of a pit with the sawed end of bone at the bottom. In this way the danger of a conical stump is eliminated. The *advantages* of the circular method are that in a fleshy limb it avoids redundance of useless muscular tissue in the stump. All the vessels being divided transversely, they contract and retract well, and unnecessary hemorrhage is avoided. The surface of the wound is smaller than in other methods, so that union is more prompt and the resulting cicatrix smaller. The *disadvantages* are that the cicatrix extends across the middle of the end of the stump and is adherent to the bone. This is liable to cause a tender stump, which in the lower extremity is particularly undesirable since the patient can not bear any weight upon it. As the corners of the stump wound are always puckered, the edges of skin do not lie in perfect apposition.

The **oval method** is similar to the circular, except that it has a longitudinal incision at one side. When this cut is very long, the incision is said to be racket-shaped. This method is best adapted to amputation of the fingers and toes.

The guillotine, or no-flap, method was extensively used during the World War mainly because it could be quickly done, especially in cases of gangrene and sepsis. On the whole, however, it did not prove so satisfactory as the flap method. Many of the men still presented edema of the stump after three or four months; reamputation of such an edematous, thickened stump is difficult to

shape, and healing in such circumstances is apt to result in distortion and in extensive puckered scars. The guillotine amputation is an emergency procedure, and should not be followed in routine amputations in civil life.

The flap methods are in reality modifications of the circular and the oval methods of amputation. In limbs that are not circular and have two parallel sides an additional incision is required in order to obtain the proper retraction of the muscle to the level of the bone.

The **transverse racket** and the **oblique racket** and **Kocher incisions** consist of a longitudinal incision added either to the circular or to the oval incision. When two such vertical incisions are made, on opposite sides of the limb in connection with a circular incision, they constitute the *equal flap* method, and when added to the oval incision they are known as the *unequal flap* method.

The *advantages* of the flap methods are that the bone is well exposed and the flaps can be fashioned from the most desirable part of the limb. The flaps come together easily after the bone has been divided and they also provide a thicker cushion for the stump, since the muscular tissue of the flaps disappears while some of the fibromuscular tissue persists. The *disadvantages* are mainly that, especially in long flaps, the blood supply is not so good as in the circular method, the muscle contracts irregularly, and the surface of the wound is larger than in the circular method.

The flaps are made either from without medialward—dissection—or from within lateralward—transfixion. The flap furthest from the main vessel is usually made first. While the transfixion method is the more rapid of the two, the skin is divided in an uneven line and the flaps are likely to be too thick. This can be avoided by dividing the skin and the superficial fascia by dissection and then dividing the muscles, the deep fascia, vessels, and nerves by transfixion. By the dissection method, the skin being divided in the most desirable manner, the flaps can be made of the proper thickness.

Amputation of the phalanges.—In amputating the phalanges: (1) save as much as possible, especially of the thumb, in order that it may be apposed to the remaining digits. (2) Do not interfere with the palm, large scars of which may cause contractures, may be painful, and develop epithelioma. (3) Do not remove the heads of the metacarpal bones except for cosmetic reasons, or divide the transverse metacarpal ligament, as the hand would thus be weakened. (4) The full breadth of the hand should be preserved.

Phalanges are usually amputated because of injury or the results of whitlow, or felon. The base of the phalanx is not always affected by necrosis, since the periosteum is protected by the insertions of the flexor and extensor tendons. In removing a portion of the finger through the continuity of the phalanx, two

oval flaps, one anterior and one posterior, are made. The palmar flap is the longer, in order to preserve as much acute tactile sense, as possible, for the end of the stump. The structures divided will depend upon the finger to be amputated and the distance of the incision from the metacarpal bone. In these amputations the skin and superficial fascia, with the collateral digital arteries which receive blood from both the radial and ulnar arteries, will be divided.

In amputations through the distal phalanges of the fingers, the tendons of the extensor digitorum communis and flexor digitorum profundus are divided; and in the second phalanx of the fingers, the tendons of the flexor digitorum sublimis, the flexor digitorum profundus, and the extensor digitorum communis are severed. In amputations of the proximal phalanx of the thumb, the tendons of the extensor primi internodii pollicis (*extensor pollicis brevis*), extensor secundi internodii pollicis (*extensor pollicis longus*), flexor pollicis longus, and of the short muscles of the thumb are divided. In amputating the distal phalanx of the thumb, the tendons of the flexor pollicis longus and extensor secundi internodii pollicis (*extensor pollicis longus*) are severed. In amputating the proximal phalanx of the fingers, the tendons of the superficial and deep flexors, the common extensor, the interosseous and lumbricales tendons are divided. In amputating through the thumb or the little finger it should be borne in mind that the flexor tendon sheaths communicate with the great palmar bursa. Infections in this synovial sac are serious. The sheaths should be closed by sutures.

The line of the interphalangeal joints is opposite the transverse furrows on the palmar surface of the fingers, and immediately to the proximal side of the ridge on the base of the respective phalanges.

In disarticulating the metacarpo-phalangeal joints the oval method is preferable. The vertical area of the incision should begin above the head of the metacarpal bone and pass distally across the middle of the knuckle to a little beyond the base of the proximal phalanx. Midway between the base of the proximal phalanx and the edge of the web of the finger the incision diverges as a Y, the arms of the Y joining in a palmar transverse incision. The structures divided are: the tendons of the common extensor, flexor digitorum sublimis, flexor digitorum profundus, interosseous and lumbricales tendons, the lateral and anterior metacarpo-phalangeal ligaments, and the collateral digital vessels and nerves.

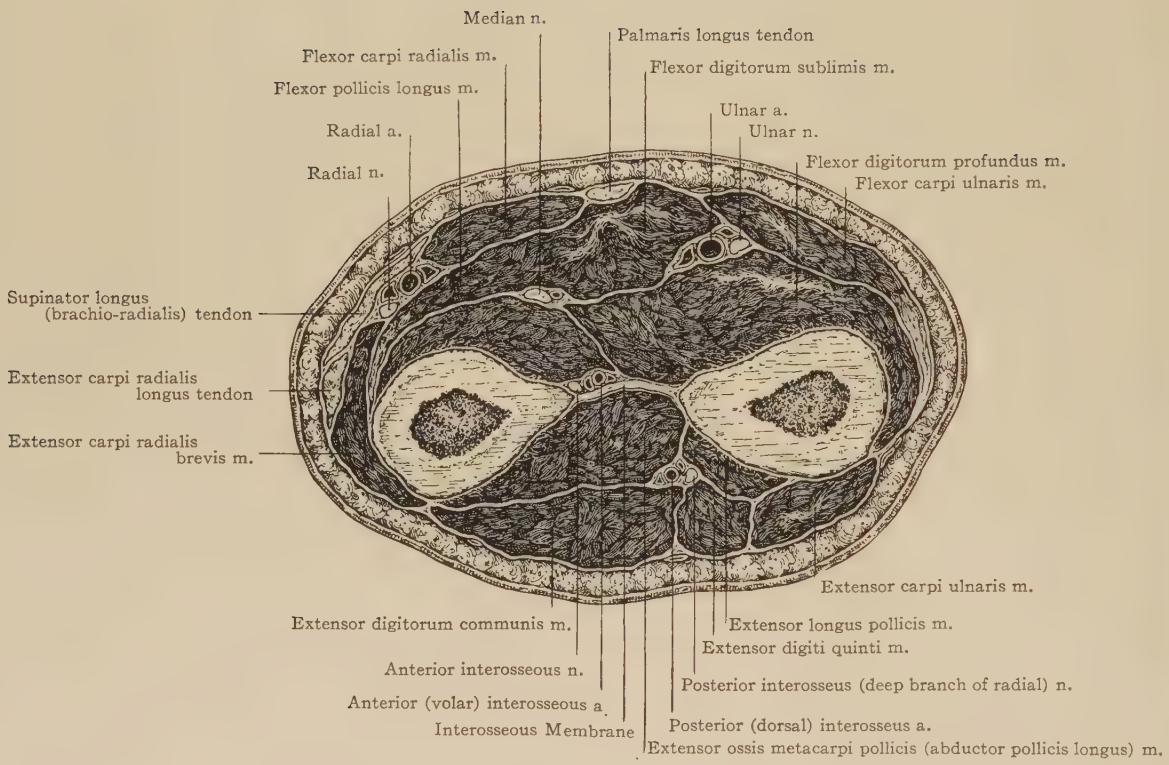
Disarticulation of the metacarpal bones.—In disarticulating these bones from the carpus the point of the knife is inserted at the junction of the metacarpal bone of the little finger with the carpus, pushed through the soft parts of the palm of the hand close to the bones, and brought out in the fleshy tissue between the thumb and the index finger. The knife is then carried downward and forward

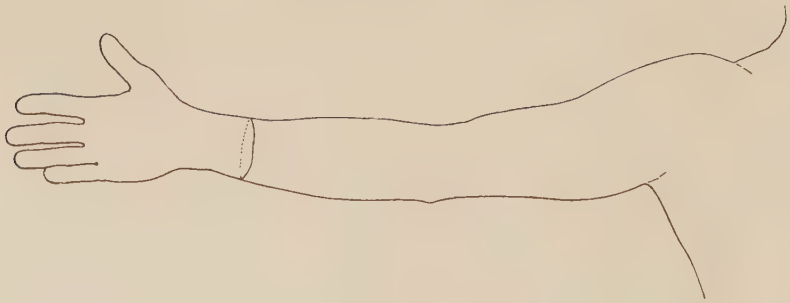
(away from the bones), cutting through the flexor brevis digiti quinti, opponens digiti quinti, abductor digiti quinti, adductor pollicis (*adductor pollicis brevis*), palmaris brevis, and lumbricales muscles, the tendons of the flexor digitorum sublimis and flexor digitorum profundus, the profunda branch of the ulnar artery and nerve, the deep palmar arch, the digital arteries and nerves, the deep and superficial palmar fasciæ, and the skin. The hand is then pronated, and a semicircular incision, with the convexity downward, is carried across the dorsal surface joining the two ends of the palmar incision. The dorsal incision divides the skin and superficial fascia, some of the radicles of the radial, anterior (*volar*) and posterior (*dorsal*) ulnar veins, branches of the radial and ulnar nerves, the deep fascia, the tendons of the extensor carpi ulnaris, extensor minimi digiti (*extensor digiti quinti proprius*), extensor digitorum communis, extensor indicis, the synovial sheaths of the tendons, the dorsal interosseous arteries, and the dorsalis indicis (*first dorsal metacarpal*). These two flaps are then dissected upward until the articulation is reached. The metacarpal bones should be disarticulated, beginning on the palmar surface. The capsular, palmar, dorsal, and interosseous ligaments are severed and the hand removed. The sheaths of the flexor and extensor tendons should be sutured, the risk of infection traveling along them being less than if they were allowed to remain open. In infected cases it is often advisable to leave the bases of the metacarpal bones so as not to open the large carpal synovial sac.

Amputation of the thumb at the carpo-metacarpal articulation.—The incision should be made along the dorsum of the trapezium (*multangulum majus*) and the first metacarpal to the head of the bone. The incision then separates in the shape of a Y, the medial arm severing the junction of the base of the thumb and the web of the fingers. In this amputation care must be taken to avoid injuring the radial artery, which is closely related to the base of the metacarpal bone of the thumb. The following structures are divided: the skin, superficial and deep fasciæ, branches of the radial and median nerves, the dorsalis pollicis and princeps pollicis arteries, the tendon of the flexor pollicis longus, the short muscles of the thumb, the abductor indicis (*first dorsal interosseus*), and the capsular ligament.

Disarticulation of the radio-carpal, or wrist-joint.—This operation is only resorted to if disarticulation at the carpo-metacarpal joint is not feasible. In order to retain the movements of pronation and supination of the stump, the wrist, rather than a higher position on the arm, is selected for the amputation. The operation is usually performed for injuries, and when the inferior (*distal*) radio-ulnar joint is unaffected. This amputation is performed by making an anterior semilunar flap with its convexity downward, and a dorsal incision with a slight upward convexity. The anterior incision extends from twelve millimeters (one

PLATE CXC.





TRANSVERSE SECTION OF FOREARM JUST BELOW MIDDLE.

half inch) below one styloid process to twelve millimeters (one half inch) below the other, and passes through the skin, the superficial fascia with its small nerves, arteries, and veins, the deep fascia, and the following structures in the order named from the ulnar to the radial side: the tendon of the flexor carpi ulnaris, the ulnar nerve, the ulnar artery and its venæ comites, the four tendons of the flexor digitorum sublimis, the four tendons of the flexor digitorum profundus, the palmaris longus, the median nerve and artery, the flexor pollicis longus, the tendon of the flexor carpi radialis, and the superficialis volæ artery.

The posterior incision divides the following structures: the skin, superficial fascia, branches of the radial and ulnar vessels and nerves, the radial, anterior (*volar*), and posterior (*dorsal*) ulnar veins, the posterior carpal branch of the ulnar artery, the tendons of the extensor carpi ulnaris, extensor digiti quinti, extensor digitorum communis, extensor indicis, extensores carpi radialis brevis and longus, extensor secundi internodii pollicis (*extensor pollicis longus*), extensor primi internodii pollicis (*extensor pollicis brevis*), extensor ossis metacarpi pollicis (*abductor pollicis longus*), the radial artery and its venæ comites, the anterior (*volar*) interosseous artery, the posterior (*dorsal*) interosseous artery and nerve, the anterior (*volar radio-carpal*), posterior (*dorsal radio-carpal*), external lateral (*radial collateral*), and internal lateral (*ulnar collateral*) ligaments.

The principal arteries to be ligated are the radial and the ulnar. The radial will be found on the radial side of the forearm, on the external lateral (*radial collateral*) ligament of the wrist-joint just below the styloid process of the radius. The ulnar will be found on the anterior aspect of the forearm, just medial to the tendon of the flexor carpi ulnaris, and lateral to the tendons of the flexor digitorum sublimis.

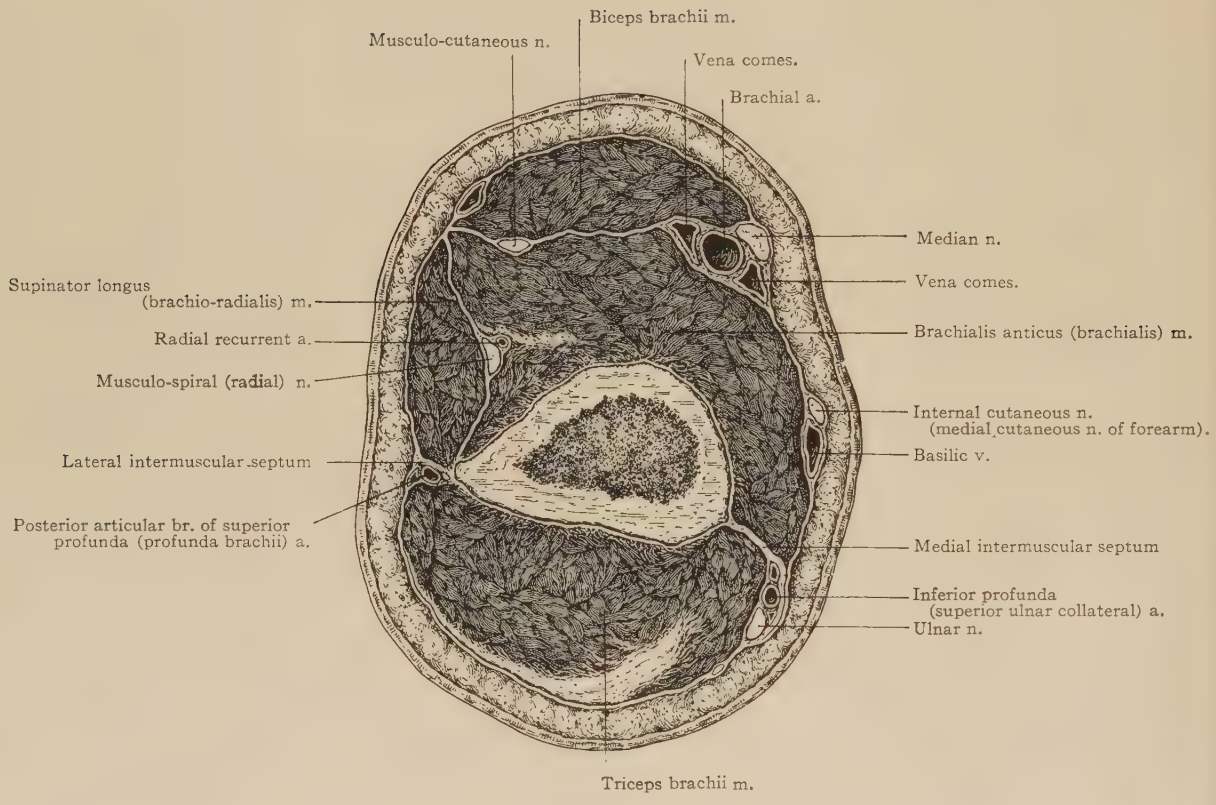
Amputation at the middle of the forearm (Plate CXC).—This operation is generally performed by the anteroposterior flap method. The anterior incision is semilunar, with its convexity downward; it passes from one border of the forearm to the other, and divides: the skin, the superficial fascia, the radial, median, and anterior (*volar*) ulnar veins, the anterior branch of the musculo-cutaneous nerve, the anterior branch of the internal cutaneous nerve (*volar branch of medial cutaneous nerve of forearm*), cutaneous branches of the radial and ulnar arteries, the deep fascia, the flexor carpi ulnaris, the ulnar vessels and nerve, the flexor digitorum sublimis, the palmaris longus, the flexor carpi radialis, the median nerve and artery, the flexor digitorum profundus, flexor pollicis longus, the radial vessels and nerve, and the supinator longus (*brachio-radialis*) muscle.

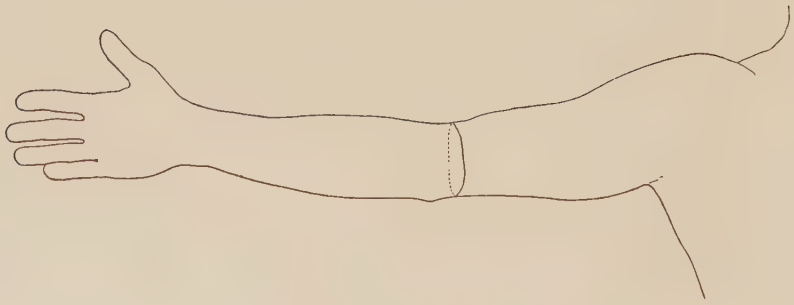
The posterior incision divides the skin, the superficial fascia, the posterior (*dorsal*) ulnar vein, the posterior branch of the internal cutaneous nerve (*ulnar branch of medial cutaneous nerve of forearm*), the inferior external cutaneous branch

(*distal branch of dorsal cutaneous nerve of forearm*) of the musculo-spiral (*radial*) nerve, the posterior branch of the musculo-cutaneous nerve, cutaneous branches of the radial and ulnar arteries, the deep fascia, the extensor carpi ulnaris, extensor minimi digiti (*extensor digiti quinti proprius*), extensor digitorum communis, extensores carpi radialis longus and brevis, extensor primi internodii pollicis (*extensor pollicis brevis*), and extensor secundi internodii pollicis (*extensor pollicis longus*), extensor ossis metacarpi pollicis (*abductor pollicis longus*), and the posterior (*dorsal*) interosseous vessels and nerve. The interosseous membrane and the anterior (*volar*) interosseous vessels and nerve are also divided. The bones should then be sawed, and the main vessels ligated. These will be the radial artery, which will be found between the pronator teres and supinator longus (*brachio-radialis*) muscles; the ulnar artery, between the flexor carpi ulnaris, the flexores digitorum sublimis and profundus; the anterior (*volar*) interosseous artery on the anterior surface of the interosseous membrane; and the posterior (*dorsal*) interosseous artery, between the superficial and deep extensors.

Disarticulation at the elbow-joint.—The most satisfactory method for performing this operation is by transfixion. The knife should be introduced about two centimeters (three-quarters of an inch) below the medial condyle (*epicondyle*) of the humerus, with the forearm supinated and slightly flexed, thus relaxing the anterior (*volar radio-carpal*) ligament so that it can be transfixed when the knife passes over the joint. The point of the knife should emerge from the radial side of the forearm the same distance below the lateral condyle (*epicondyle*). The knife should then be carried down the forearm for about ten centimeters (four inches) and brought abruptly to the surface. The structures severed will be: the anterior ligament of the joint, the brachialis and the supinator brevis (*supinator*) muscles, the posterior interosseous nerve, the tendon of the biceps, the extensor carpi radialis longus, the supinator longus (*brachio-radialis*), the flexor digitorum profundus, flexor pollicis longus, the common interosseous, or anterior (*volar*), and the posterior (*dorsal*) interosseous vessels, the anterior (*volar*) interosseous nerve, the median artery and nerve, the radial vessels and nerve, the ulnar vessels and nerve, the posterior ulnar recurrent artery, the superficial flexors, the deep fascia, the superficial fascia, the radial, the anterior and posterior ulnar, and the median veins, the anterior and posterior branches of the musculo-cutaneous nerve, the anterior branch of the internal cutaneous nerve (*volar branch of medial cutaneous nerve of forearm*), and the skin. A posterior incision should then be made directly across the back of the forearm, over the base of the olecranon, so as to connect the two ends of the anterior incision, when a flap of skin and superficial fascia is raised as high as the tip of the olecranon. This incision divides the skin, the superficial fascia, the inferior external cutaneous branch (*distal branch*

PLATE CXCI.





TRANSVERSE SECTION OF ARM ABOVE CONDYLES (EPICONDYLES) OF HUMERUS.

of dorsal cutaneous nerve of forearm) of the musculo-spiral (*radial*), and the posterior branch of the internal cutaneous nerve (*ulnar branch of medial cutaneous nerve of forearm*). The knife should then be passed between the head of the radius and the humerus, then across the front of the joint between the coronoid process of the ulna and the humerus, severing the internal lateral (*ulnar collateral*) and external lateral (*radial collateral*) ligaments and part of the posterior ligament. Next saw through the base of the olecranon, and remove the forearm by cutting the supinator brevis (*supinator*), the interosseous recurrent artery, the anconeus, the extensor carpi radialis brevis, extensor digitorum communis, extensor carpi ulnaris, flexor carpi ulnaris, and the deep fascia.

The principal vessels to be ligated are: the radial, ulnar, common interosseous, or anterior (*volar*), and the posterior (*dorsal*) interosseous, the posterior ulnar recurrent, and the interosseous recurrent arteries. The radial artery will be found on the radial side of the flap, just beneath the ulnar margin of the supinator longus (*brachio-radialis*) muscle. The ulnar artery will be found between the flexor digitorum sublimis and the flexor carpi ulnaris. The common, or anterior (*volar*), and the posterior (*dorsal*) interosseous arteries will be severed near their origins.

Amputation through the middle of the arm (Plate CXCI).—In this amputation the circular or the anteroposterior flap method may be used. In either the following structures will be severed on the front and medial side of the arm: skin, superficial fascia, the intercosto-humeral (*intercosto-brachial*) nerve, the internal cutaneous (*posterior cutaneous nerve of arm*) and external cutaneous (*dorsal cutaneous nerve of forearm*) branches of the musculo-spiral (*radial*) nerve, a cutaneous branch of the circumflex (*axillary*) nerve, the lesser internal cutaneous nerve (*medial cutaneous nerve of arm*) (nerve of Wrisberg), internal cutaneous nerve (*medial cutaneous nerve of forearm*), branches of the superior profunda (*profunda brachii*) and inferior profunda (*superior ulnar collateral*) arteries, the cephalic vein, the deep fascia, the biceps and the brachialis muscles, the musculo-cutaneous nerve, the median nerve, the brachial artery and its venæ comites, the basilic vein, and the ulnar nerve; on the posterior aspect of the arm, the triceps muscle, the musculo-spiral (*radial*) nerve and the superior profunda (*profunda brachii*) artery will be seen immediately behind the bone, in close relation to that structure, and the brachial artery beneath the medial border of the biceps.

Disarticulation at the shoulder-joint is performed for injury, malignant tumors of the upper extremity, and occasionally for disease of the joint. Only one of the numerous methods for disarticulation at the shoulder-joint is described, because practically the same structures are divided in all methods. The most important requisite is a knowledge of the anatomy of the parts rather than of the different

operations. Hemorrhage is best controlled by the use of a rubber tube kept in place with Wyeth's pins. The anterior pin enters at a point slightly medial to the middle of the anterior axillary fold and emerges at a point two and a half centimeters (one inch) medial to the tip of the acromion. The posterior pin is inserted opposite the anterior pin and emerges at a similar point, posterior to the acromion process. The author prefers Spence's operation, a modification of the oval method. It is especially adapted to those cases of injury where there has been much comminution of the humerus. The posterior circumflex artery is not severed, the head of the bone can be disarticulated very readily, and the resulting stump is generally full and round. The incision extends from a point just lateral to the coracoid process, downward, in a line with the humerus, to a point just below the attachment of the pectoralis major muscle. The following structures are divided: skin, superficial fascia, supra-acromial branches of the cervical plexus of nerves, branches of the anterior and posterior circumflex vessels, the deep fascia, the cephalic vein, the humeral (*deltoid*) branch of the acromio-thoracic (*thoraco-acromial*) artery, the deltoid, the pectoralis major muscles, and the anterior circumflex vessels. The incision is then carried backward, in a gentle curve, to the posterior border of the axilla. The skin and superficial fascia, with twigs of the posterior circumflex artery and circumflex (*axillary*) nerve, the cephalic vein, the deep fascia, and the deltoid muscle will be severed.

The posterior flap can now be readily stripped from the bone and joint. The flap will carry with it the terminal part of the circumflex (*axillary*) nerve and the posterior circumflex vessels which enter its deep surface. The muscles attached to the greater tuberosity are then severed. They are the supraspinatus, infraspinatus, and teres minor. The subscapularis is next detached from the lesser tuberosity, the long head of the biceps divided, and the joint opened by dividing the capsular ligament. The arm is carried well medialward, thus causing the head of the humerus to pass from the glenoid cavity. Before proceeding further a slight dissection of the axilla may be made to expose the axillary vessels, which may then be ligated before the remaining soft parts are severed; or the knife may be carried downward close to the bone on its medial aspect, the insertions of the teres major and latissimus dorsi muscles severed, and the anterior flap made by cutting from within outward. Care must be taken to have an assistant follow the knife downward with his fingers in contact with the vessels, and that the lateral cut is not made until the surgeon is sure that the vessels are controlled by the assistant. This is not necessary if the vessels are controlled by a tourniquet. The last incision severs the triceps muscle, the brachial vessels, the basilic vein, the anterior circumflex artery, the ulnar, median, musculo-spiral (*radial*), the internal cutaneous (*medial cutaneous nerve of forearm*), lesser inter-

nal cutaneous (*medial cutaneous nerve of arm*), internal cutaneous branch (*posterior cutaneous nerve of arm*) of the musculo-spiral (*radial*), and the intercosto-humeral (*intercosto-brachial*) nerves, the deep fascia, superficial fascia, and the skin.

LIGATION OF THE ARTERIES

Anatomy of an Artery.—The wall of an artery is composed of three coats: an internal, a middle, and an external.

The *internal coat*, or *tunica intima*, is composed of a layer of flat endothelial cells which lines the vessel wall, and an elastic layer (*internal elastic membrane*) which is chiefly composed of yellow elastic fibers arranged in a mesh-work, the majority of the fibers of which are in a longitudinal direction. This layer is united to the layer of endothelial cells by delicate areolar tissue. When an artery is ligated, the internal coat curls inward and retracts, thus partially occluding the lumen of the artery and giving support to the clot of blood which undergoes organization. When an artery is completely divided, this coat curls inward and retracts in the same manner as when it is ruptured in ligation of a vessel.

The *middle coat*, or *tunica media*, is composed chiefly of circular unstriped muscle and some elastic fibers. The muscle fibers predominate in the smaller vessels, and the elastic tissue in the larger vessels. When an artery is completely divided, it is chiefly through this coat that it contracts, while retraction is produced by both the internal and the middle coat.

The *external coat*, or *tunica adventitia*, is composed chiefly of white fibrous tissue and some longitudinal elastic fibers; this is the only coat of an artery which is not ruptured in ligation of a vessel. The adventitia carries the vasa vasorum and the chief lymph channels of the vascular wall. It also carries the periarterial vaso-motor sympathetics. It is this sheath which is removed in the Leriché operation of periarterial sympathectomy.

With the exception of the intracranial arteries and the ascending portion of the arch of the aorta, all arteries are covered by a **sheath** of connective tissue, and are more or less connected with it by strands of fibrillar connective tissue. Some arteries, such as the common carotid and common femoral, have an additional sheath formed by the deep fascia. The sheath is loosely attached to the outer coat of the vessel and the surrounding structures, and gives support to the vessel wall.

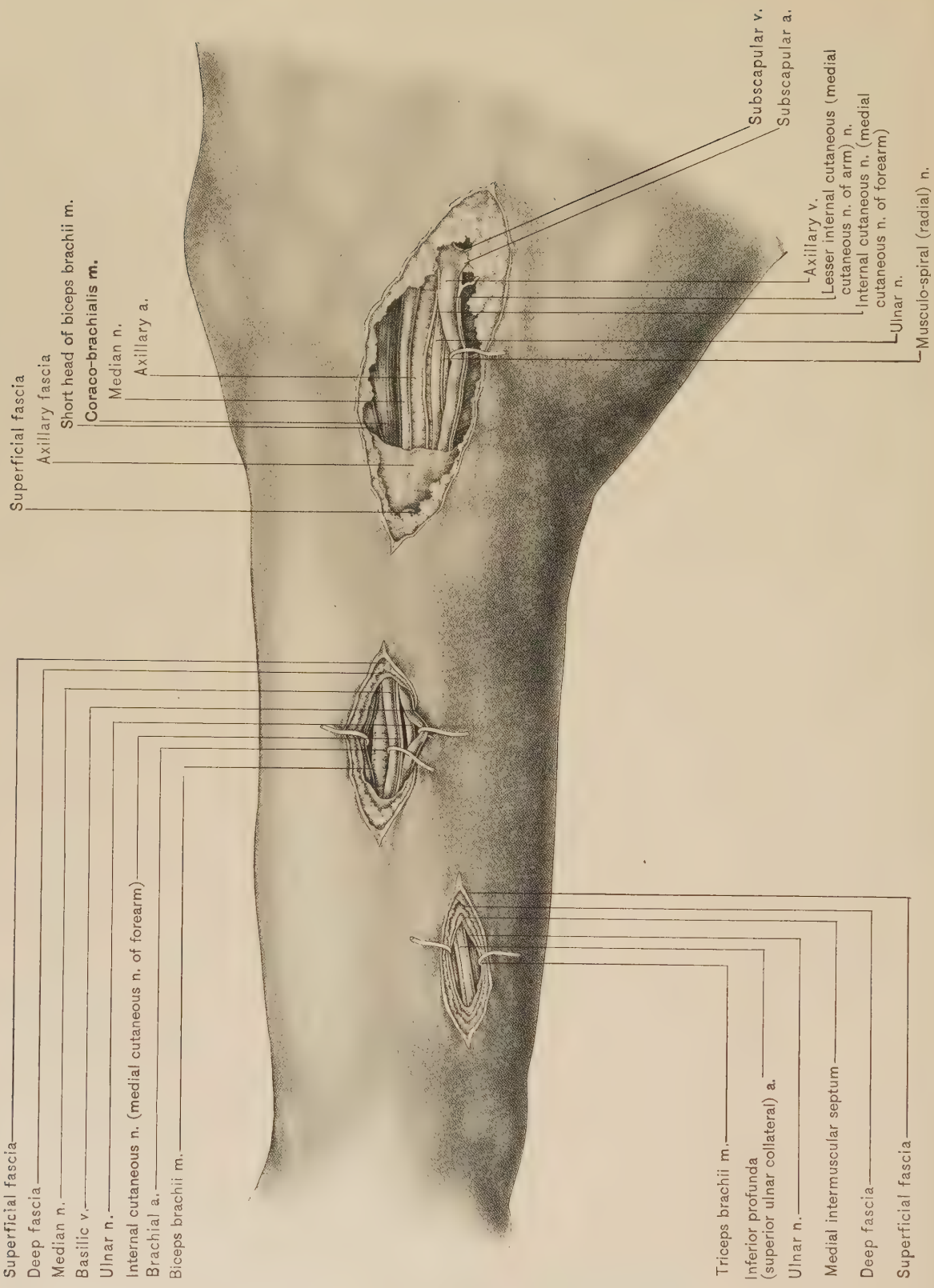
When ligating an artery, it is customary to open the sheath and separate it from the vessel for a short distance before passing the aneurysm needle.

Arteries are ligated in the treatment of aneurysms; to arrest hemorrhage; check malignant growths, and previous to some operations, such as disarticulation at the shoulder and removal of the tongue.

In the **Ligation of Arteries** familiarity with the following rules is necessary: the ligature must not be placed too near an aneurysm because it is there that the coats of the artery are diseased. But if too great a distance is allowed to intervene between the aneurysm and the point of ligation, the collateral circulation is too quickly established and blood passes through the sac, displaces the clot, and prevents organization. The ligature must not be too near a large branch, as the current of blood would then prevent clot formation and organization, and thus increase the risk of secondary hemorrhage when the ligature is absorbed. The operator must be well acquainted with the course and the anatomic relations of the vessel, with its anomalous forms and relations, and its superficial and deep landmarks. The incision is made over the vessel and parallel to it. It should be sufficiently long to give ample room for the application of the ligature. As soon as the skin and fasciæ are divided, locate the anatomic guides to the artery and then search for the vessel, the pulsation of which will assist in finding it. All of the small superficial vessels and nerves are divided, while large ones should be avoided and displaced. Each layer of tissue over the vessel is carefully divided so that the anatomic landmarks may not be lost. The cut edges of the different layers are separated, but separation of these layers is avoided as much as possible. After the sheath of the vessel is exposed, it is carefully cleaned for a short distance and a small portion of it is pinched up and divided with the knife held flat, with its cutting edge away from the vessel. The opening in the sheath should be very small. After the sheath is opened, only enough of it is separated from the artery to allow the aneurysm needle to be passed. A blunt aneurysm needle is used to carry the ligature under the artery. The needle is always passed away from the structure which would be most endangered. If one vein accompanies the artery, the needle is passed away from the vein; if the artery has two venæ comites and one accompanying nerve, the needle is passed away from the nerve. The needle may be passed either armed or unarmed. In passing the needle no force should be used, and if obstruction is met with a slight change in position may overcome it. Before the needle is withdrawn always compress the artery between the curve of the needle and the finger, and notice whether the pulsation in the artery or its branches beyond the site of the operation is checked and whether any other structures will be included in the ligature. The ligature should always be tied at a right angle to the course of the artery, for if placed obliquely, it is apt to become loose. The ligature is tied with a reef-knot or a surgical knot, firmly but without traction. In large vessels a second ligature just below the first gives added security.

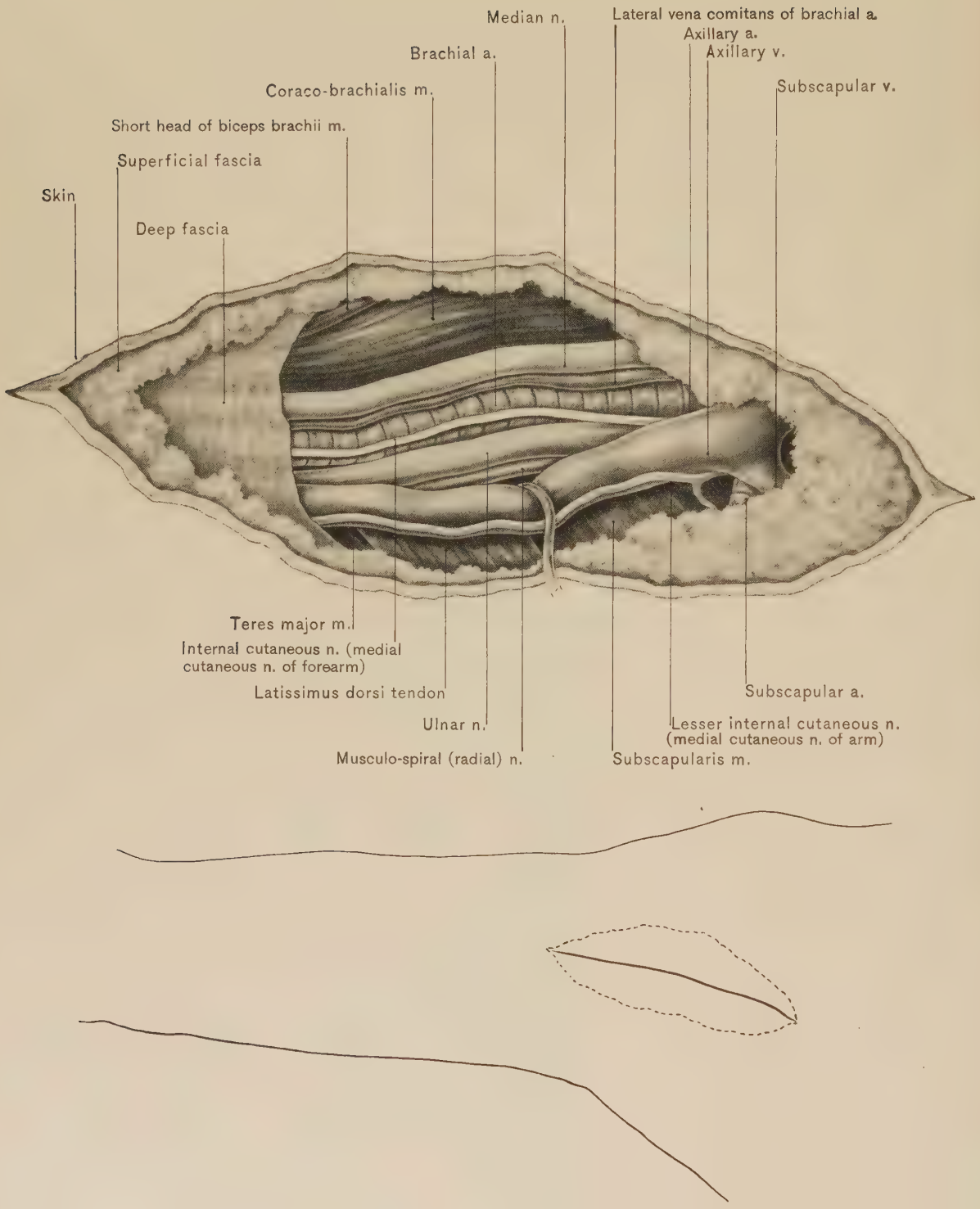
The undesirable sequelæ of ligation of an artery are: hemorrhage from loosening of the ligature, secondary hemorrhage from the breaking down of diseased

PLATE CXCII.



OPERATIONS FOR EXPOSURE OF THIRD PART, AXILLARY ARTERY AND LARGE BRANCHES OF BRACHIAL ARTERY; BRACHIAL ARTERY AND MEDIAN NERVE AT MIDDLE OF ARM AND ULNAR NERVE IN DISTAL HALF OF ARM.

PLATE CXCIII.



THIRD PORTION,—AXILLARY ARTERY AND LARGE BRANCHES OF BRACHIAL PLEXUS.

vessel walls, sloughing around the ligature or imperfect organization of the clot, and rupture of the vessel. Gangrene of the limb upon the distal side of the ligature may occur from slow and insufficient establishment of the collateral circulation. Sloughing of the sac may also result. The pulsation in the sac may continue or recur, either because the ligature was placed obliquely and became loosened, or was placed too far above the sac; or because the collateral circulation has been too rapidly established through free anastomosis of branches above and below the ligature, or because of the presence of a vas aberrans.

The **axillary artery** begins at the lower border of the first rib, and extends as far as the inferior margin of the tendon of the teres major muscle. With the arm abducted to a right angle with the body, the course of the artery is represented by a line drawn from just medial to the middle of the clavicle to the middle of the bend of the elbow. The artery is divided into three parts by the pectoralis minor muscle. The different portions of the artery have been described on pp. 65 and 66. As a rule, the axillary artery is ligated only in its third portion (Plates CXCII; CXCIII). In ligating this portion of the artery the arm should be abducted to a right angle with the body. An incision is made in the line of the vessel, beginning at the middle of the floor of the axilla. It is then carried downward about seven centimeters (three inches) along the medial border of the coracobrachialis muscle, which can be easily felt. The skin and superficial fascia, with small branches of the intercosto-humeral (*intercosto-brachial*), internal cutaneous nerve (*medial cutaneous nerve of forearm*), lesser internal cutaneous nerve (*medial cutaneous nerve of arm*), and branches of the long thoracic (*lateral thoracic*) artery, are divided. The deep fascia is then incised, and the medial margin of the coracobrachialis muscle exposed. The coraco-brachialis is drawn lateralward, and the position of the artery determined by its pulsation. The median nerve will then be exposed and should be drawn lateralward, while the internal cutaneous nerve (*medial cutaneous nerve of forearm*) is drawn medialward. The lateral venæ comites of the brachial artery and the axillary vein being well exposed, the ligature should be passed around the artery from within outward, well below the origin of the circumflex branches.

Unusual forms and relations of the axillary artery are the following: the third portion of the artery may be covered by a muscular slip (*the axillary arch*) from the latissimus dorsi. There may be two large arterial trunks instead of one; one of them may be a common trunk of origin for the long thoracic (*lateral thoracic*), subscapular, posterior circumflex, and superior profunda (*profunda brachii*) arteries, while the other is the continuation of the axillary, and continues to form the brachial; or one of the trunks may be a radial or an ulnar artery with an unusually high origin. When several of the branches of the axillary arise

from a common trunk, as already stated, the main branches of the brachial plexus may surround this trunk and therefore be useless as landmarks for locating the main trunk of the axil ary artery.

The *collateral circulation* after ligation of the third part of the axillary artery (Plate CXCIV) above the origin of the subscapular is established by the anastomosis

of	with
the suprascapular (*transverse scapular*) and acromio-thoracic (*thoraco-acromial*) arteries	the anterior and posterior circumflex arteries;
the suprascapular, (*transverse scapular*), posterior scapular (*descending branch of transverse cervical*), and long (*lateral*) thoracic arteries	the dorsalis scapulæ (*circumflex scapular*) and subscapular arteries;
the intercostal branches of the aorta and the internal mammary artery	the subscapular artery.

When the artery is tied between the origins of the subscapular and circumflex arteries, the collateral circulation is established by the anastomosis

of	with
the suprascapular (*transverse scapular*) and acromio-thoracic (*thoraco-acromial*) arteries	the anterior and posterior circumflex arteries;
the subscapular artery	the posterior circumflex artery.

The subscapular artery (Plate CXCV).—With the arm abducted to a right angle with the body, the artery is exposed by an incision made through the floor of the axilla along the anterior border of the posterior fold of the axilla. The skin, superficial fascia, superficial vessels, posterior branches of the lateral cutaneous nerves, and the axillary fascia, are divided. The artery is found to the medial side of the anterior border of the latissimus dorsi, lying in the areolar tissue in front of the subscapularis muscle. The incision should avoid the axillary vessels which are upon the lateral wall of the axilla. The *long subscapular (thoraco-dorsal) nerve* lies to the medial side of the upper third of the artery and in intimate relation with the middle third. The *subscapular vein* lies in front of the artery at its origin, and holds a varying relation to the remainder of the artery. The *dorsalis scapulæ (circumflex scapular) artery* arises from the subscapular artery about two and a half centimeters (one inch) from the origin of the latter. The *lower subscapular* nerve passes toward the teres major muscle just above or below the position of the dorsalis scapulæ (*circumflex scapular*) artery.

PLATE CXCIV.

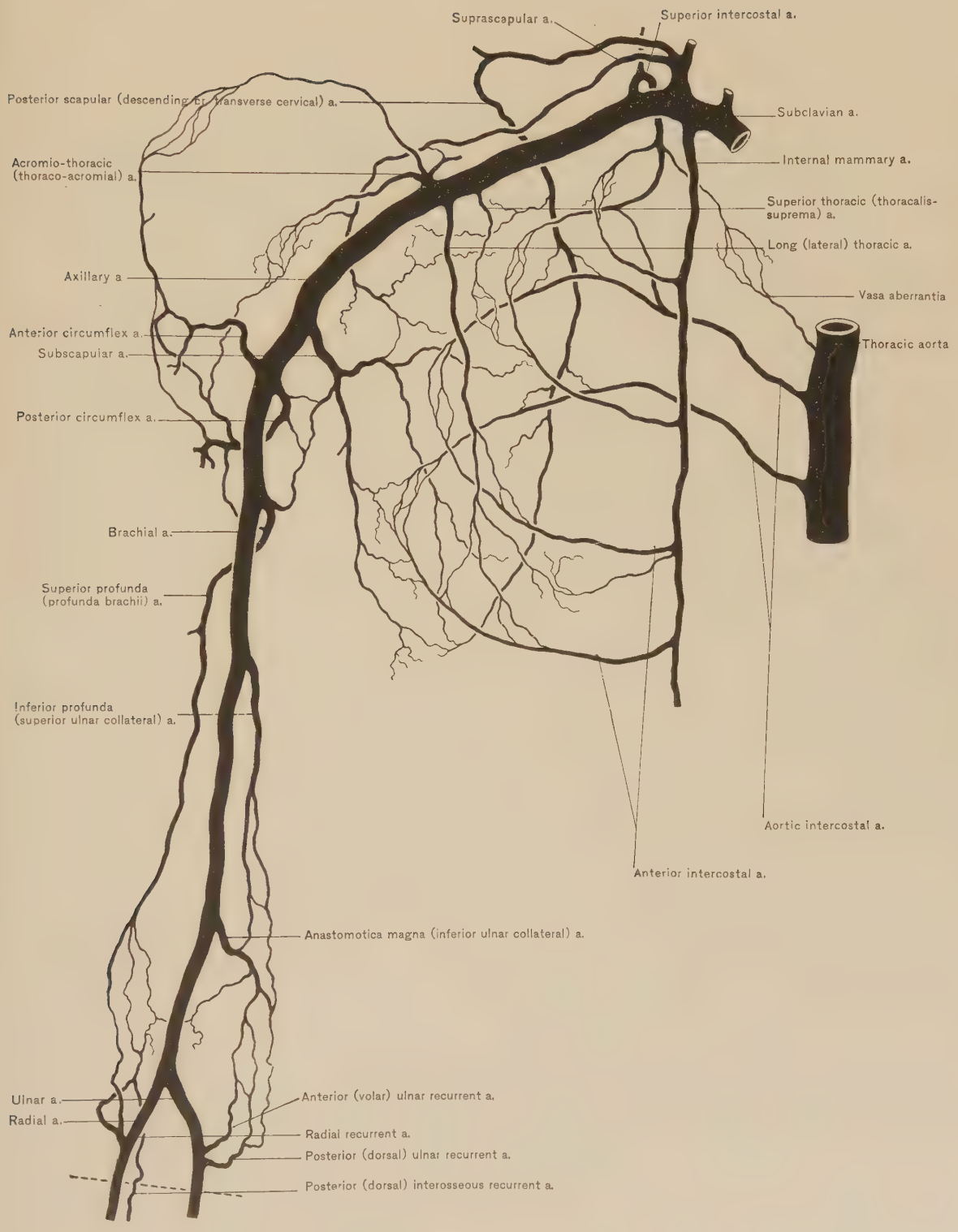
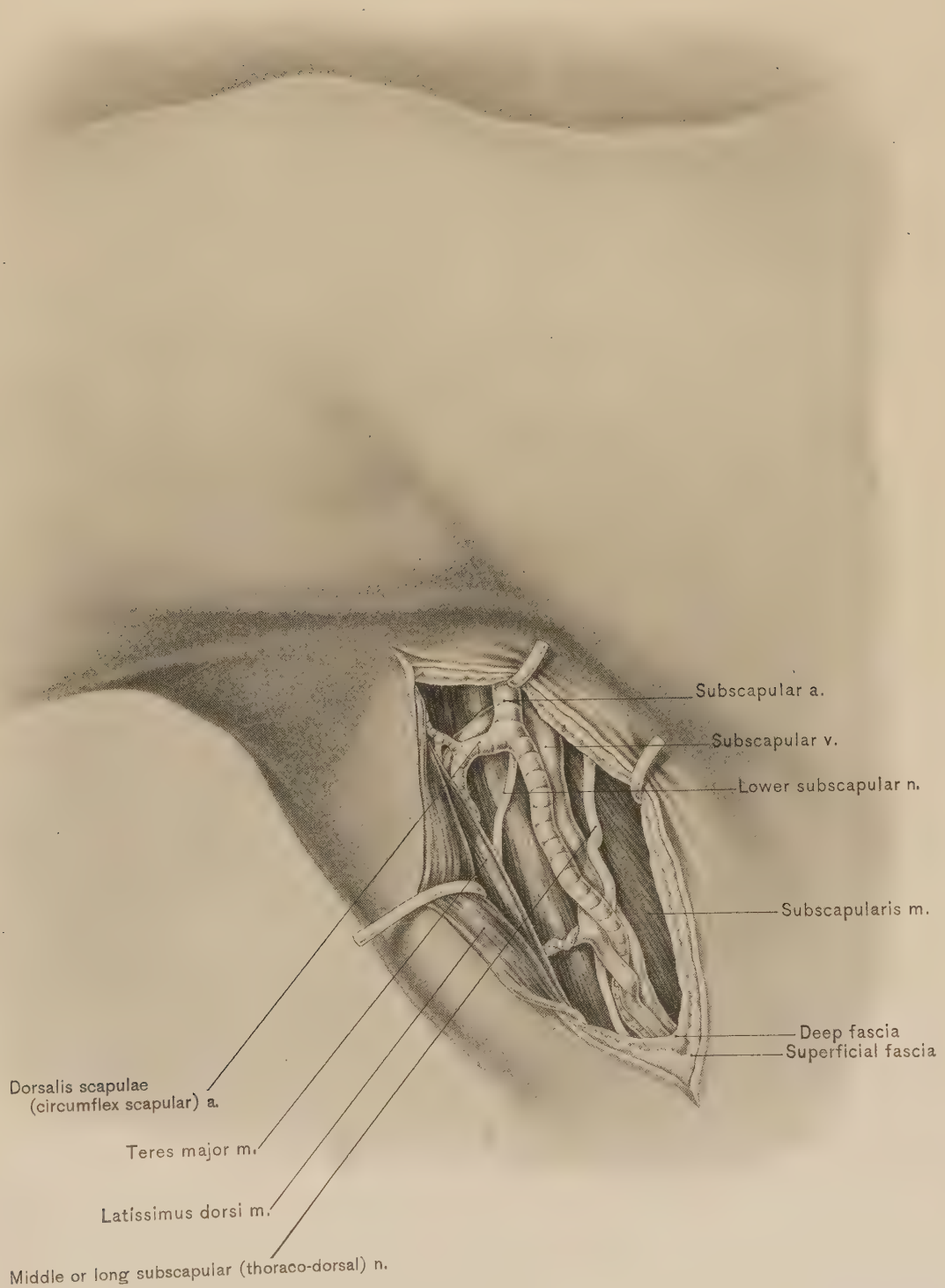
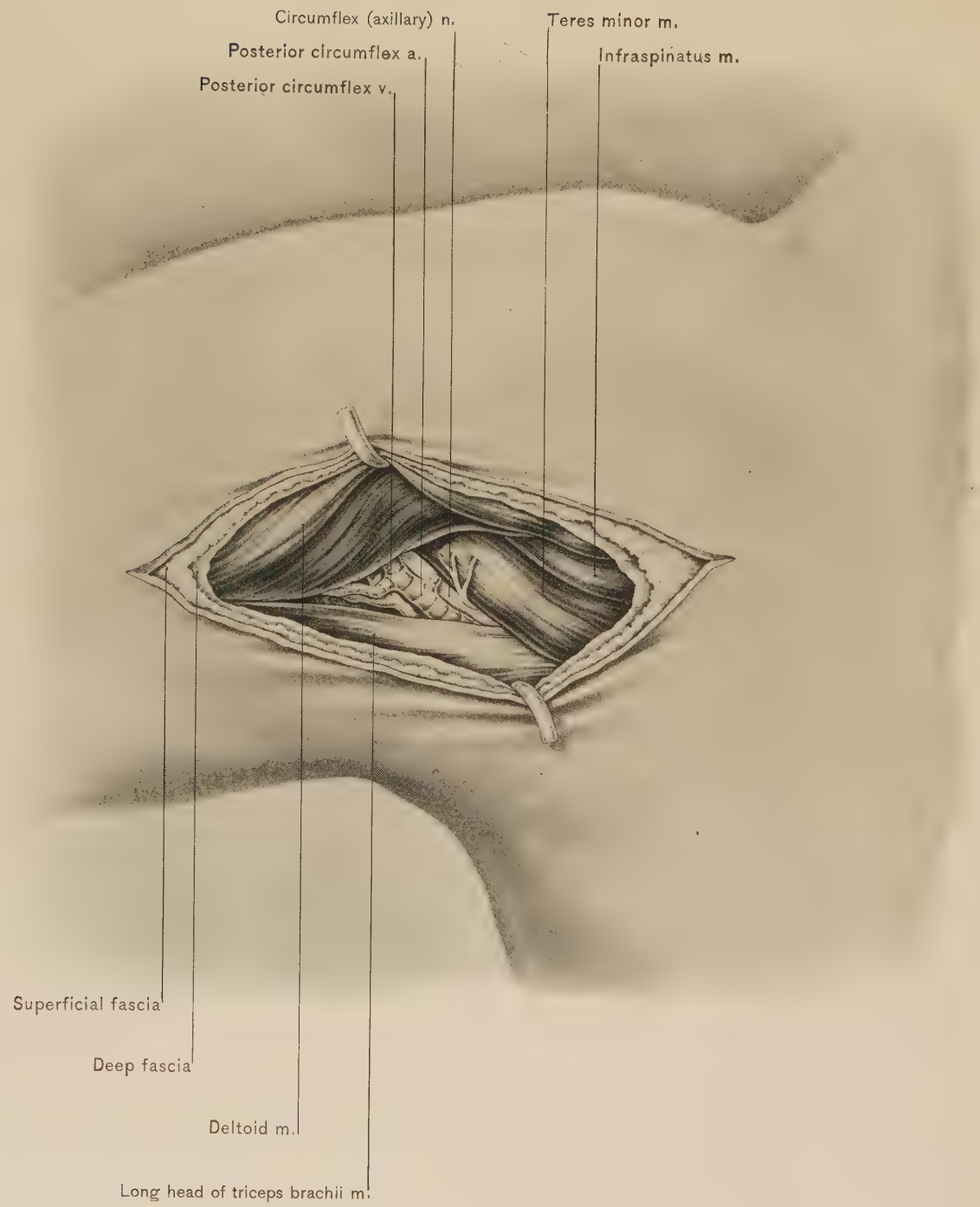


DIAGRAM OF COLLATERAL CIRCULATION AFTER LIGATION OF AXILLARY AND BRACHIAL ARTERIES.



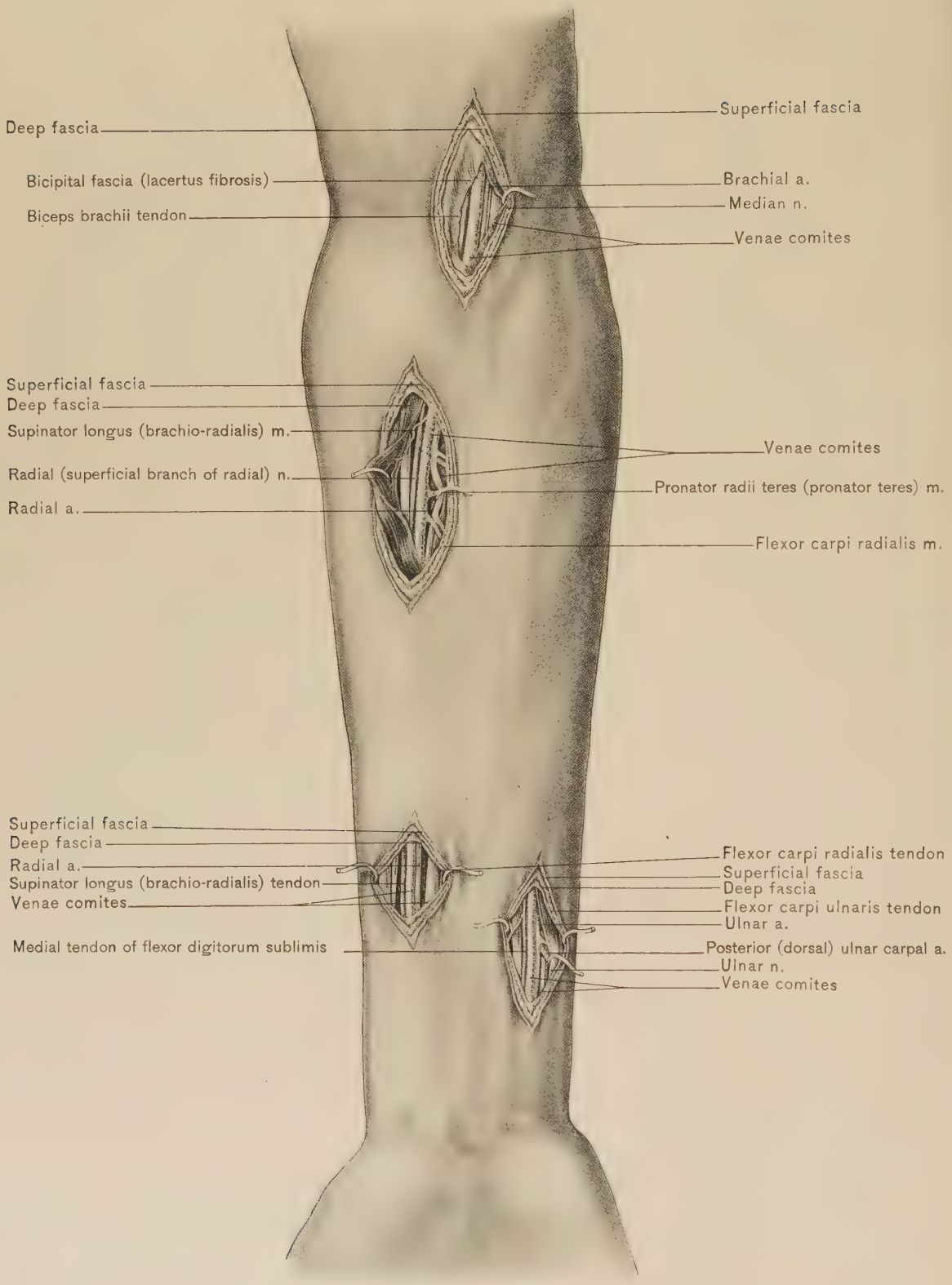
SUBSCAPULAR ARTERY, MIDDLE SUBSCAPULAR (THORACO-DORSAL) AND LOWER SUBSCAPULAR NERVES.

PLATE CXCVI.



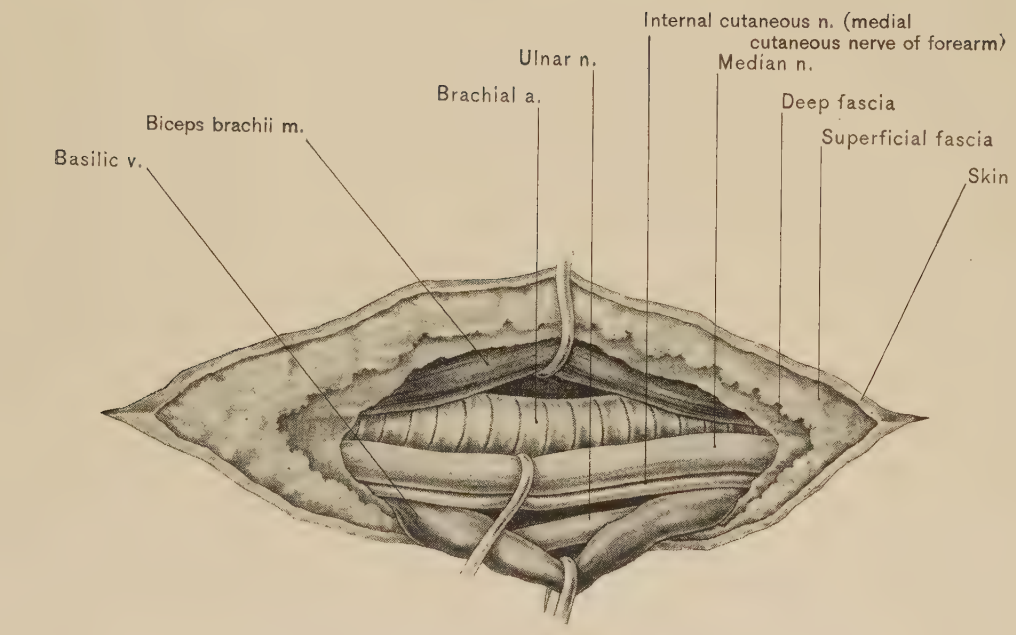
POSTERIOR CIRCUMFLEX ARTERY AND CIRCUMFLEX (AXILLARY) NERVE.

PLATE CXCVII.

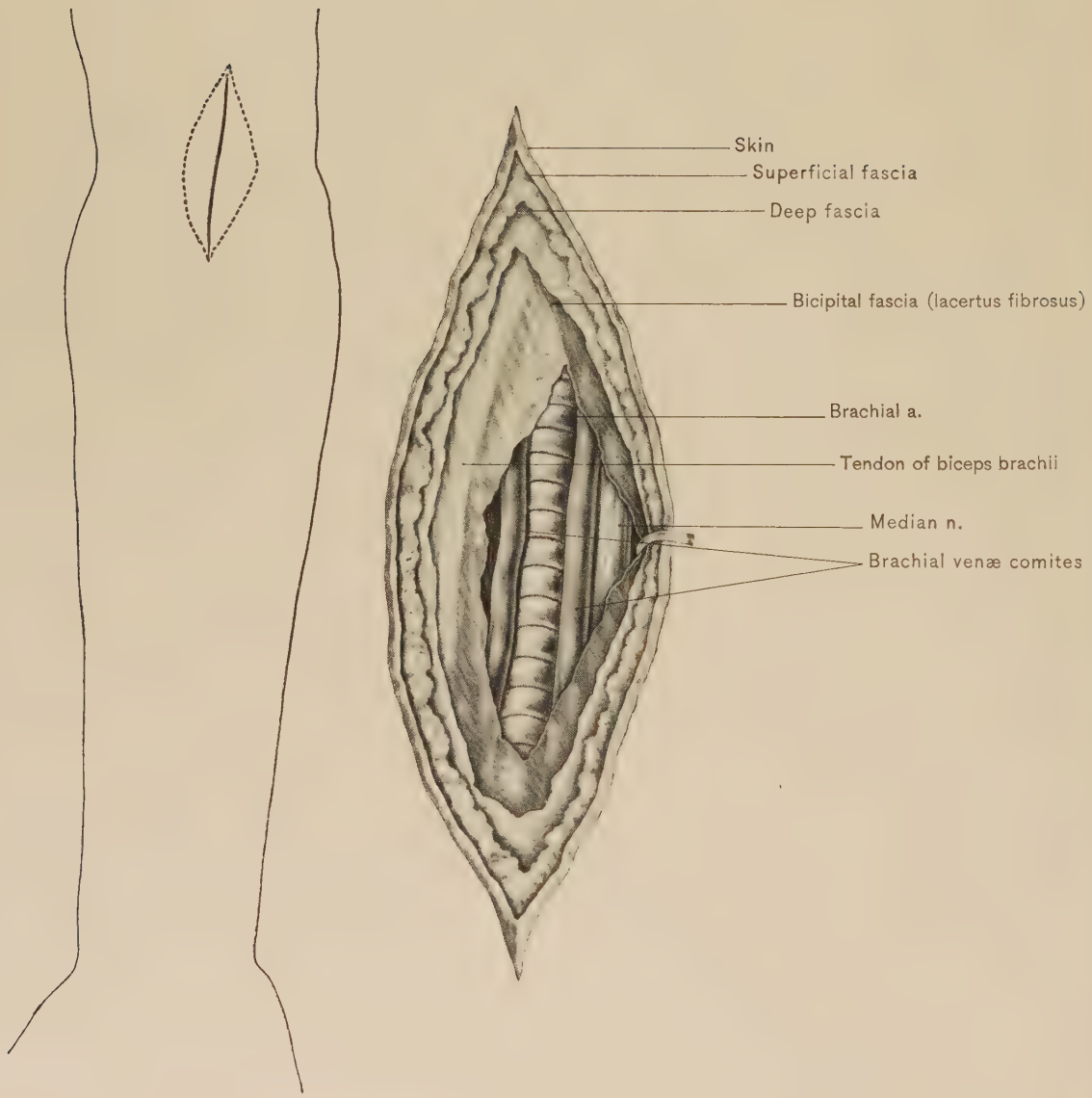


BRACHIAL ARTERY AND MEDIAN NERVE AT ELBOW, RADIAL ARTERY AND RADIAL (SUPERFICIAL BRANCH OF RADIAL) NERVE AT MIDDLE OF FOREARM, RADIAL ARTERY IN DISTAL THIRD OF FOREARM, AND ULNAR ARTERY AND NERVE ABOVE WRIST.

PLATE CXCVIII.



BRACHIAL ARTERY AND MEDIAN NERVE AT MIDDLE OF ARM.



BRACHIAL ARTERY AND MEDIAN NERVE AT ELBOW.

The **posterior circumflex artery** and the **circumflex (axillary) nerve** (Plate CXCVI) are most readily found upon the dorsal surface of the shoulder as they emerge from the quadrangular space to supply the deltoid. The arm is abducted to a right angle with the body, and the incision is made along the posterior border of the deltoid. The center of the incision should be at the angle formed by this border of the deltoid and the axillary border of the scapula. The skin and fasciæ are divided and the deltoid is drawn forward. The long head of the triceps and the inferior margin of the teres minor are now seen, and the finger may be introduced into the wound to detect the pulsation of the artery as it winds around the surgical neck of the humerus. The nerve lies upon the superior side of the artery. The quadrangular space is bounded upon the lateral side by the humerus, upon the medial side by the long head of the triceps, superiorly by the teres minor, and inferiorly by the teres major. As the nerve passes through the space it supplies a branch to the teres minor, branches to the deltoid, and gives off cutaneous branches to the skin over the deltoid.

The **brachial artery** has been described at p. 93. It is the continuation of the axillary artery, and begins at the lower edge of the tendon of the teres major muscle. Its course is on the same line as the axillary artery (Plate CXCVII; CXCVIII; CXCVIIIA).

The **brachial artery** may be ligated at the bend of the elbow, or at the middle of the arm. In ligating it *at the bend of the elbow*, the forearm is in supination and the arm slightly flexed in order to make prominent the tendon of the biceps. The median, median basilic, median cephalic, and deep median veins usually join on a level with the point where the tendon ceases to be felt distinctly. Having located these points, the forearm should be extended and the arm abducted. An incision, about five centimeters (two inches) long, is made along the medial edge of the tendon of the biceps, the proximal end of the incision being about on a level with the tip of the medial condyle (*epicondyle*). The skin, superficial fascia, the anterior branch of the internal cutaneous (*medial cutaneous nerve of forearm*) and branches of the external cutaneous (*lateral cutaneous nerve of forearm*), twigs from the inferior profunda (*superior ulnar collateral*) and anastomotica magna (*inferior ulnar collateral*) arteries, with their veins, are severed. The median basilic vein will be found lying on the medial side of, and parallel with the incision, and should be drawn distally and medially as soon as exposed. The deep fascia and bicipital fascia (*lacertus fibrosus*) are divided in the line of the original incision, and the artery with its venæ comites and the median nerve, which lies to its medial side, exposed. The median nerve should be retracted medially, the veins should be separated from the artery, its sheath opened, and the ligature passed around the artery from within outward.

Ligation of the brachial artery at the bend of the elbow is not advisable, because scars should not be made at flexures of joints.

In ligating the brachial artery in *the middle of the arm*, the incision is made along the medial edge of the biceps muscle, being careful not to injure the internal cutaneous nerve (*medial cutaneous nerve of forearm*) and the basilic vein, both of these being kept posterior to the incision. The skin, superficial fascia, twigs of the internal cutaneous (*medial cutaneous nerve of forearm*) nerve, and small branches of the superior profunda (*profunda brachii*) and anterior circumflex arteries will be divided. The deep fascia is then incised and the medial edge of the biceps muscle clearly demonstrated. The muscle is displaced lateralward, and the position of the artery determined by its pulsations. The median nerve is then exposed, generally lying over the artery in this part of its course. It should be drawn medialward and the sheath of the vessel opened. The venæ comites are then separated from the artery, and the ligature passed from within outward away from the basilic vein.

After ligation of the brachial artery above the origin of the superior profunda (*profunda brachii*) artery, the *collateral circulation* is established by anastomosis

of	with
the anterior circumflex	the superior profunda (*profunda brachii*);
the posterior circumflex	the inferior profunda (*superior ulnar collateral*).

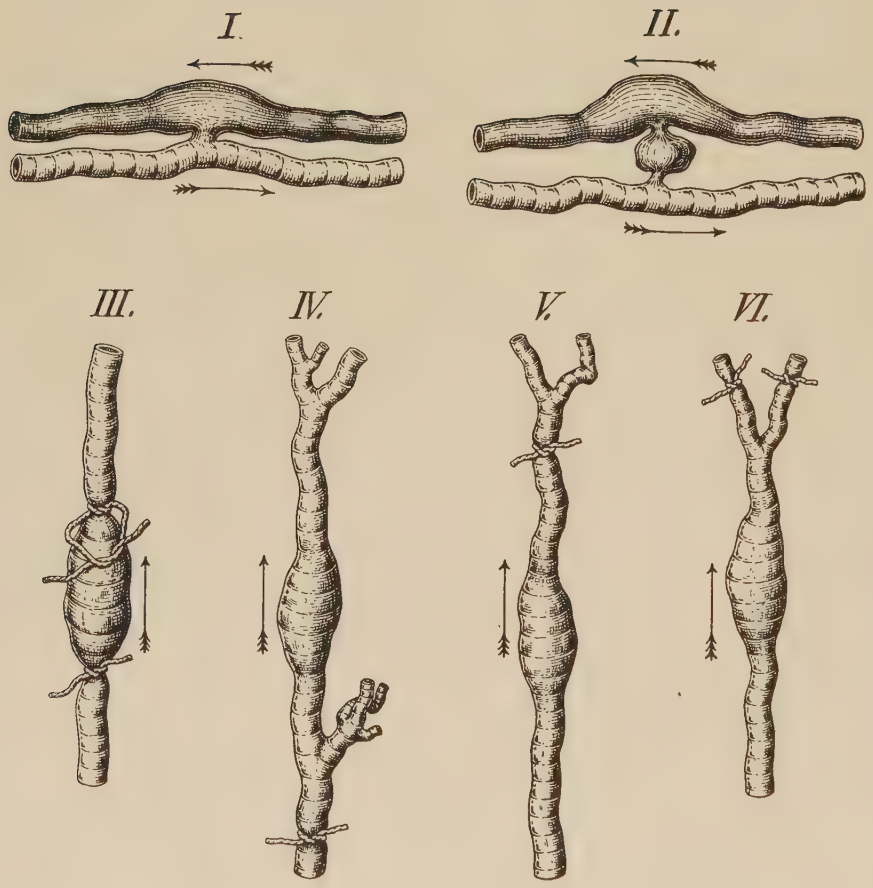
After ligation of the brachial artery at the middle of the arm the circulation is reëstablished by the anastomosis

of	with
the superior profunda (*profunda brachii*) artery	the anastomotica magna (*inferior ulnar collateral*), radial recurrent, and interosseous recurrent arteries;
the inferior profunda (*superior ulnar collateral*) artery	the anastomotica magna (*inferior ulnar collateral*), anterior ulnar recurrent, and posterior ulnar recurrent arteries.

After ligation of the brachial artery at the bend of the elbow the circulation is reëstablished by the anastomosis

of	with
the superior profunda (*profunda brachii*) and anastomotica magna (*superior ulnar collateral*) arteries	the radial recurrent and interosseous recurrent arteries;
the inferior profunda (*superior ulnar collateral*) and anastomotica magna (*inferior ulnar collateral*) arteries	the anterior ulnar recurrent and posterior ulnar recurrent arteries.

PLATE CXCIX.



I. ANEURYSMAL VARIX. II. VARICOSE ANEURYSM. III. METHOD OF ANTYLLUS. IV. HUNTER'S METHOD. V. BRASDOR'S METHOD. VI. WARDROP'S METHOD.

In ligating the brachial artery it should be remembered that frequently there are two large arteries in the arm instead of one. This is due to the high origin of either the radial or ulnar artery, or to the presence of a vas aberrans. A third head of origin of the biceps sometimes crosses in front of the brachial artery near the middle of the arm. The median nerve is sometimes under instead of over the middle portion of the artery. The brachial artery and the median nerve rarely pass toward the posterior surface of the medial condyle (*epicondyle*), but pass around the supracondyloid process and then in front of the elbow. This artery is most readily compressed at the middle of the arm where it lies upon the coraco-brachialis muscle; it is usually ligated in this location.

The brachial artery is sometimes ligated for an arteriovenous aneurysm, usually caused by a wound which involves both the artery and the adjacent median basilic vein or venæ comites, but it may occasionally result from disease.

Arteriovenous aneurysms are of two varieties: aneurysmal varix and varicose aneurysm (Plate CXCIX). In an *aneurysmal varix* the wounds of the artery and vein have adhered and become closely united by inflammatory exudate; there is formed a direct connection between the artery and the vein, and the arterial blood passes directly into the vein, each pulsation dilating it and causing regurgitation through its valves. There ensues distention and a varicose condition of the adjacent superficial and deep veins. These veins become elongated, tortuous, thickened, and may pulsate, but a characteristic aneurysm is not formed. In a *varicose aneurysm* the inflammatory exudate which binds together the wounds in the artery and vein yields, and a sac is formed by distention of the channel which connects the two vessels. The blood passes from the artery through the connecting channel and its sac into the vein. The most common cause of varicose aneurysm in connection with the brachial artery is venesection practised upon the median basilic vein, which crosses the brachial artery. It seldom results if a needle is used for venesection, or if the vein is exposed before it is incised. Punctured or gunshot wounds, however, may also cause a varicose aneurysm.

In both varieties of arteriovenous aneurysm there is pulsating dilatation of the veins, a thrill, and a continuous murmur. The murmur is heard along the course of the veins toward the heart. In the varicose form a murmur may be detected at the position of the sac, and there is always a thrill synchronous with the beat of the heart.

If arteriovenous aneurysm gives rise to any disturbing symptoms operation should be resorted to. Occasionally, the connection between the two vessels can be ligated and cut, but it may be necessary to do a plastic operation. According to Matas, shortly after the injury efforts should be made to favor spontane-

ous cure by gentle pressure over the anastomosis and on the main artery on the proximal side of the anastomosis, or by simple digital compression of the main artery, and by rest and immobilization.

When ligating the **radial artery** *in the distal third of the forearm* (Plate CC), the incision is made along the line of the artery, represented by a line drawn from a point one and a quarter centimeters (one-half inch) below the center of the bend of the elbow to the radial pulse, that is, just to the ulnar side of the styloid process of the radius, between and parallel with the tendons of the supinator longus (*brachio-radialis*) and flexor carpi radialis muscles. In order to avoid the origin of the superficial radial vein the incision should not extend below the level of the tuberosity of the scaphoid. After the deep fascia is incised, the space between the tendons is plainly seen. After the venæ comites have been separated, the artery is exposed and the ligature passed in either direction. When the venæ comites cannot be separated, they should be included with the artery in the ligature.

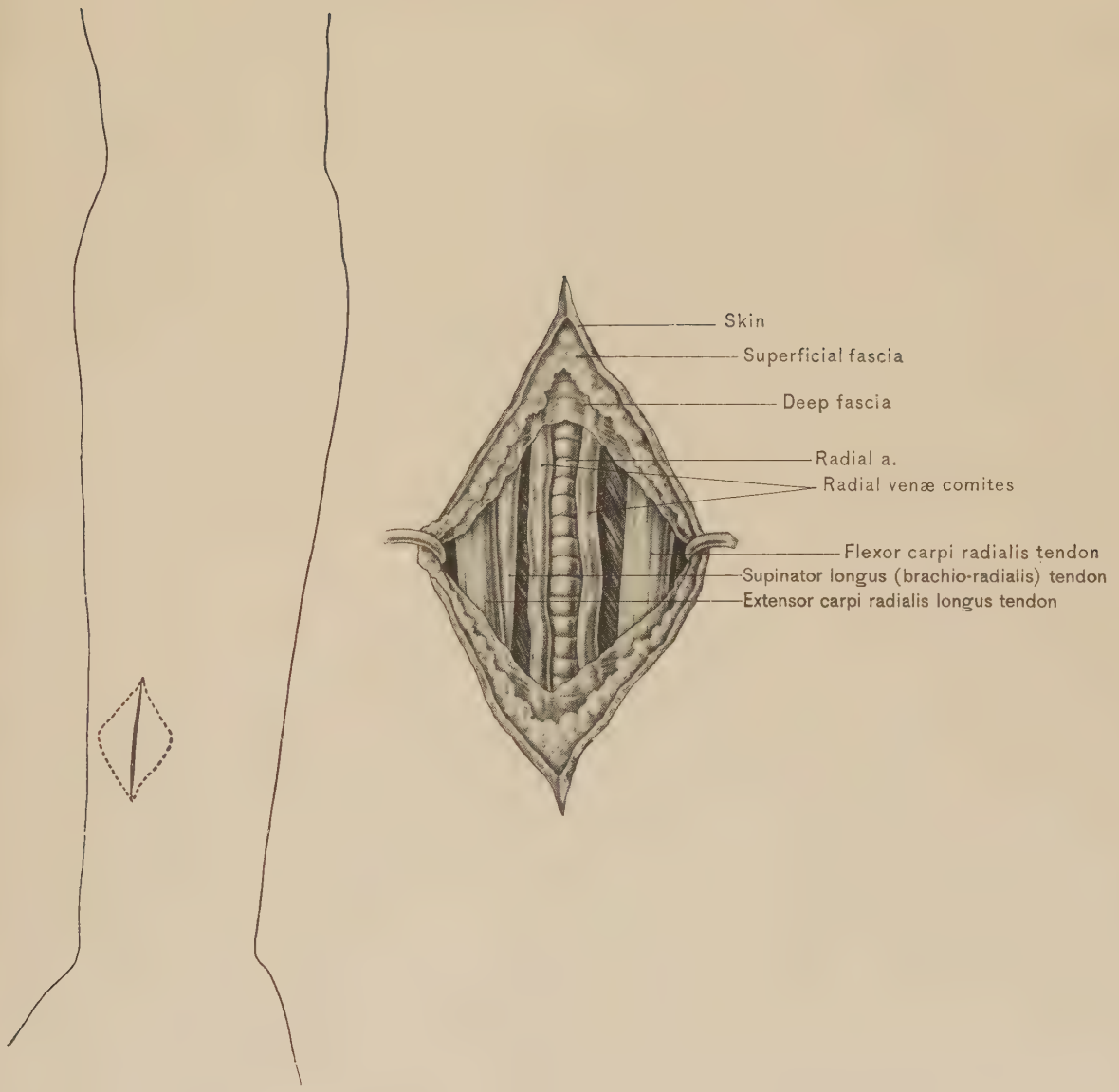
When ligating the radial artery *in the middle of the forearm,* the incision is made over the line of the vessel (Plate CCI). The deep fascia is incised and the supinator longus (*brachio-radialis*) muscle exposed. This muscle is drawn lateralward and the vessel located by its pulsations. It will be found lying upon the insertion of the pronator teres muscle. The venæ comites should be separated from the artery, and the ligature passed around the latter from without inward.

In ligating the radial artery *in the proximal third* the incision is made over the course of the vessel. Sometimes some of the large superficial veins of the forearm which are divided may cause considerable hemorrhage. The deep fascia is incised, and the space between the supinator longus (*brachio-radialis*) and the pronator teres muscles opened up. The radial artery will be found under the supinator longus (*brachio-radialis*) muscle. The ligature may be passed from either side.

To ligate the radial artery *in the "anatomic snuff box"* (Plate CCII) carry an incision in the long axis of this triangular interval, midway between the tendons of the extensores primi internodii pollicis (*extensor pollicis brevis*) and secundi internodii pollicis (*extensor pollicis longus*). Divide the skin and superficial fascia, avoiding injury to the radial vein and the branch of the radial nerve supplying the thumb. Next divide the deep fascia, when the artery with its venæ comites will be exposed.

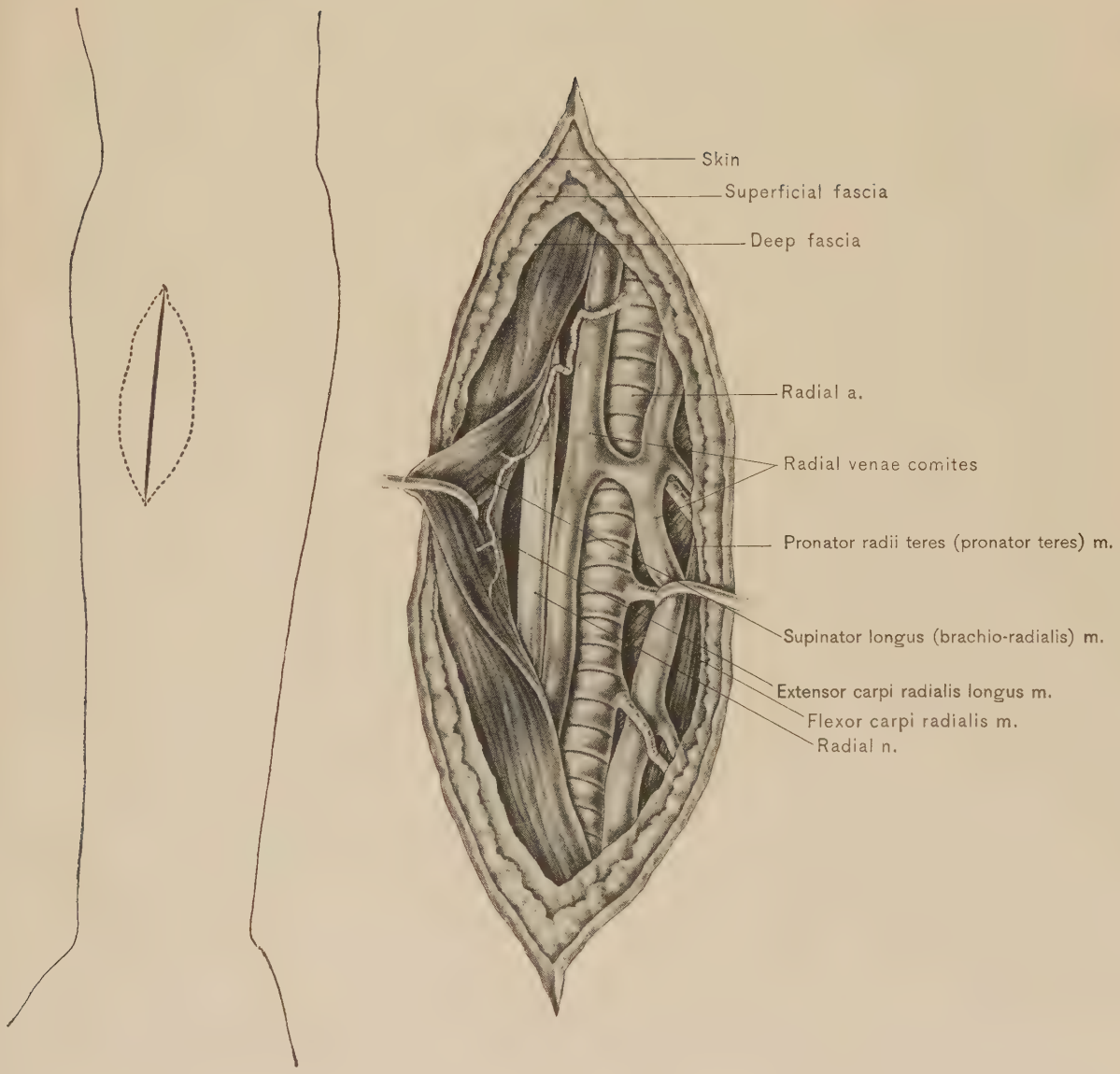
The radial artery may arise from the brachial artery in the arm or from the axillary artery, and is at times quite superficial, overlying the supinator longus (*brachio-radialis*) muscle.

PLATE CC.



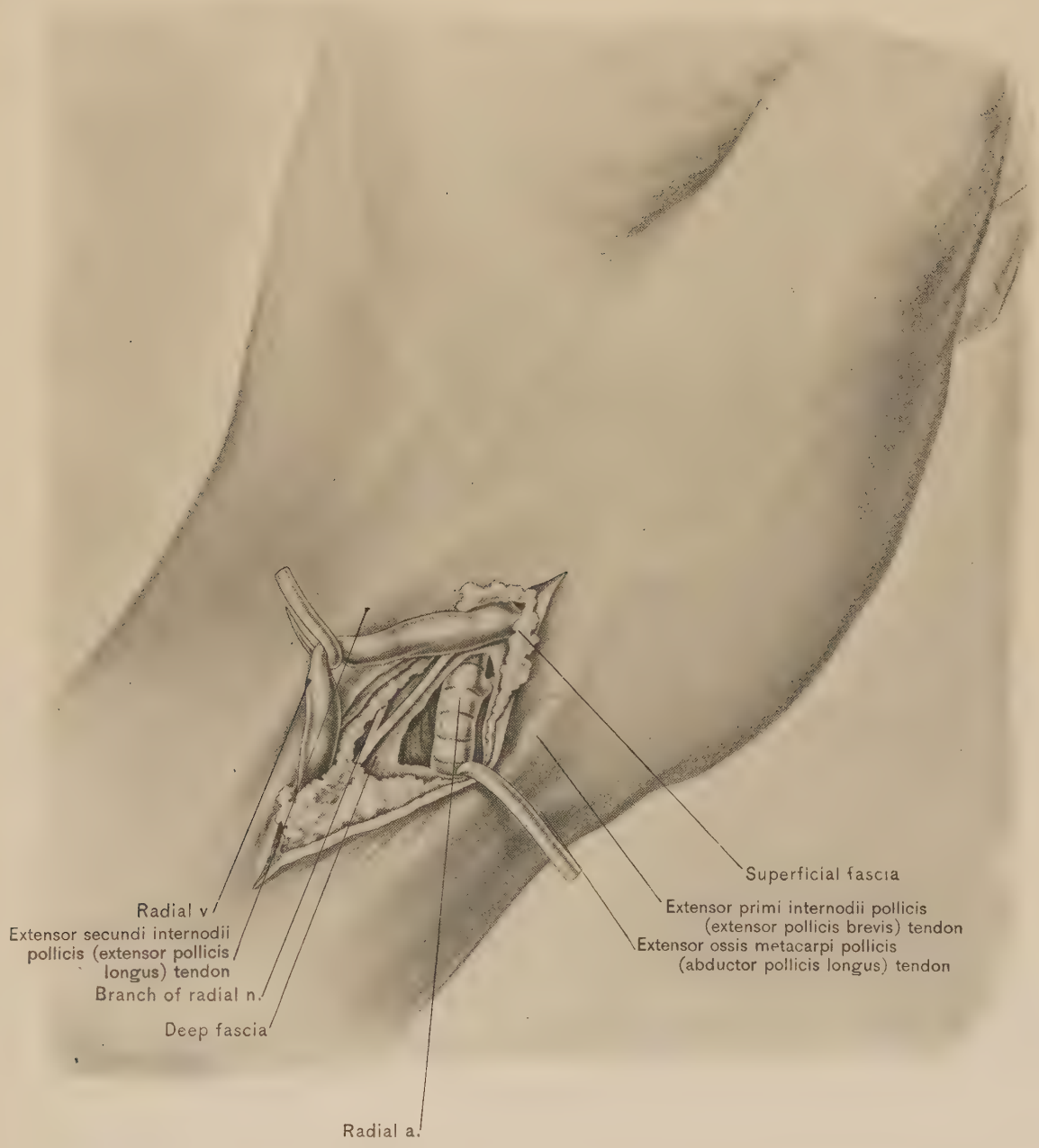
RADIAL ARTERY ABOVE WRIST.

PLATE CCI.



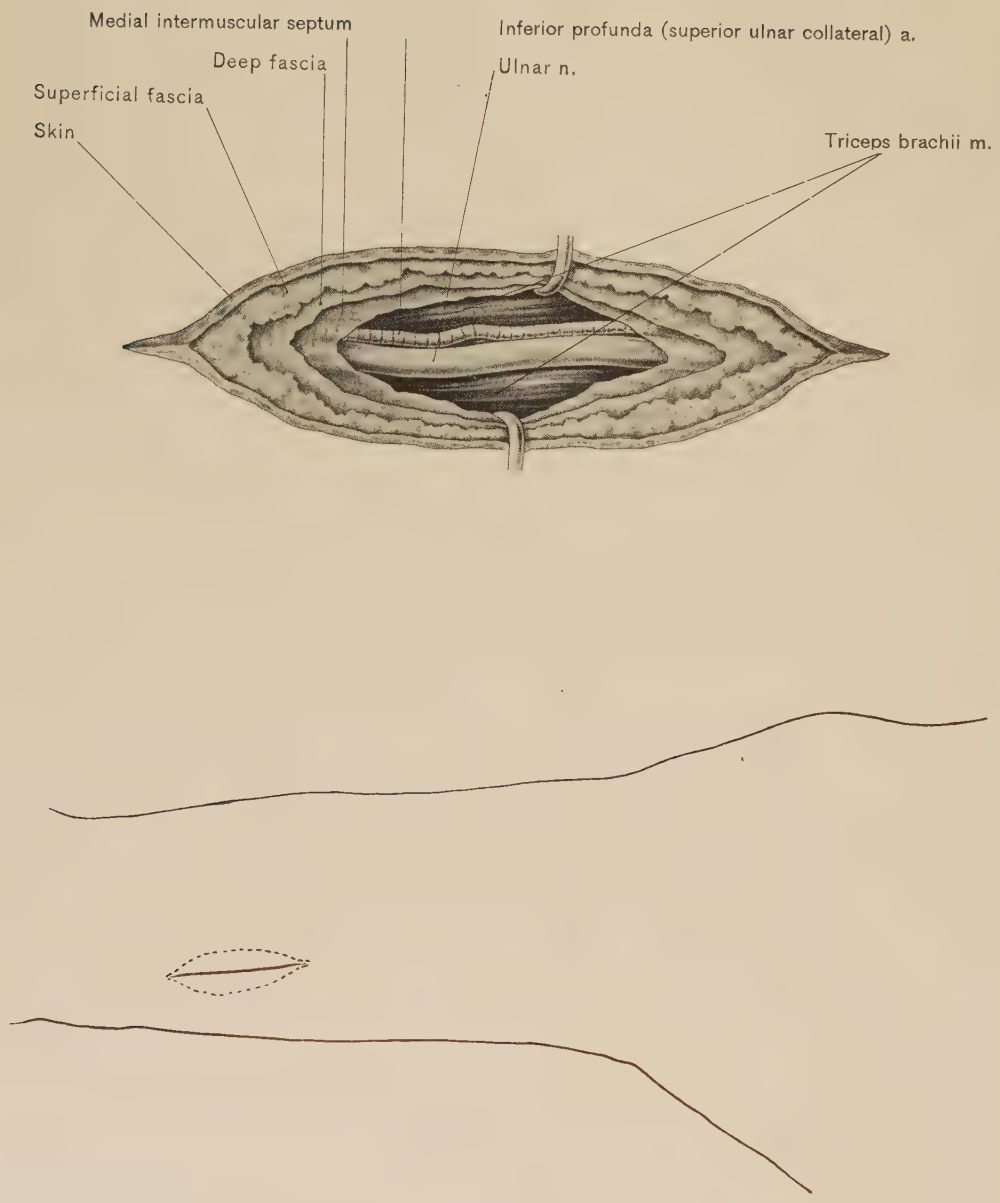
RADIAL ARTERY AND NERVE AT MIDDLE OF FOREARM.

PLATE CCII.

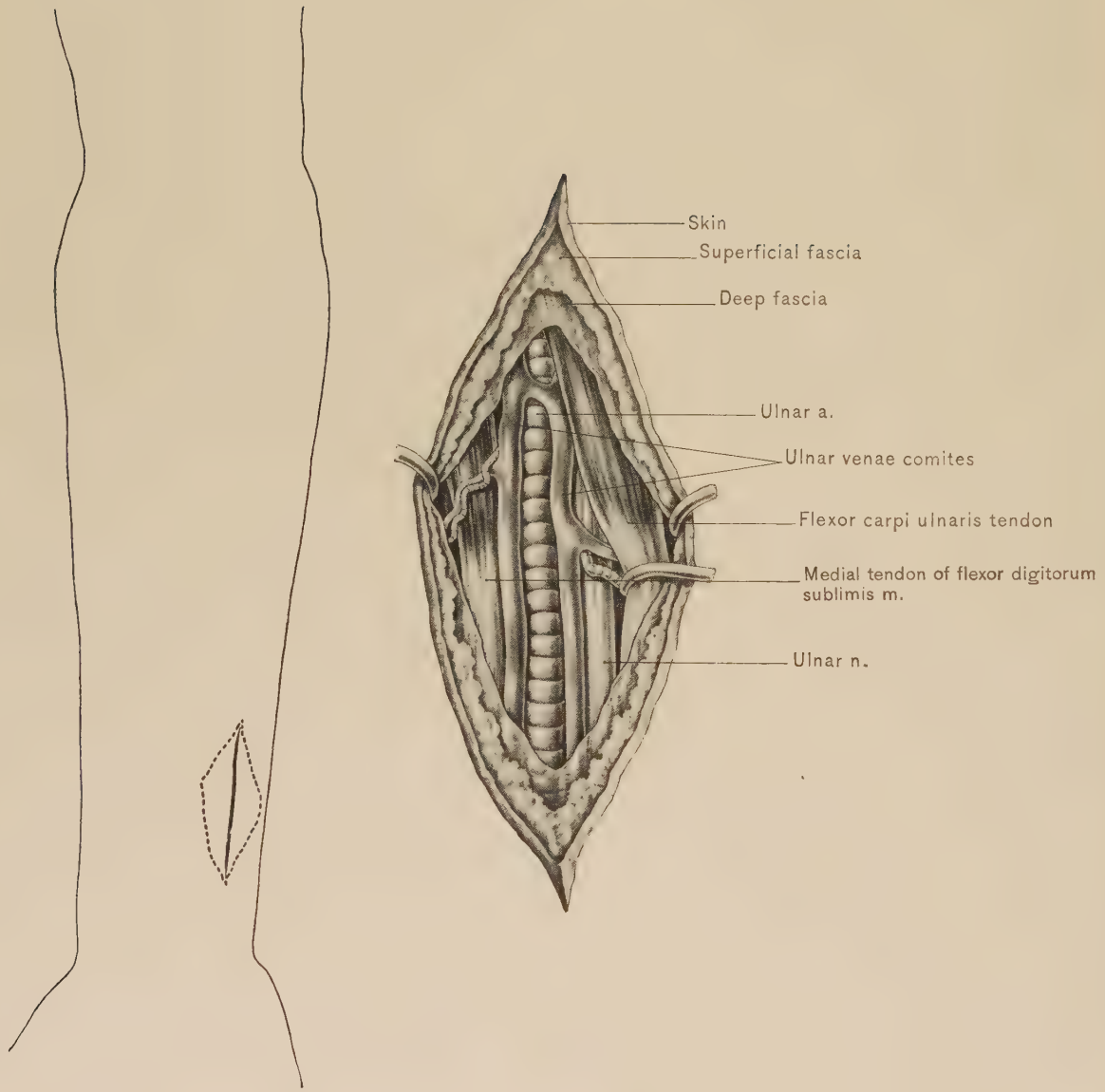

Radial v.
Extensor secundi internodii pollicis (extensor pollicis longus) tendon
Branch of radial n.
Deep fascia
Radial a.
Superficial fascia
Extensor primi internodii pollicis (extensor pollicis brevis) tendon
Extensor ossis metacarpi pollicis (abductor pollicis longus) tendon

RADIAL ARTERY IN "SNUFF-BOX."

PLATE CCIII.



ULNAR NERVE IN DISTAL HALF OF ARM.



ULNAR ARTERY AND ULNAR NERVE ABOVE WRIST.

PLATE CCV.

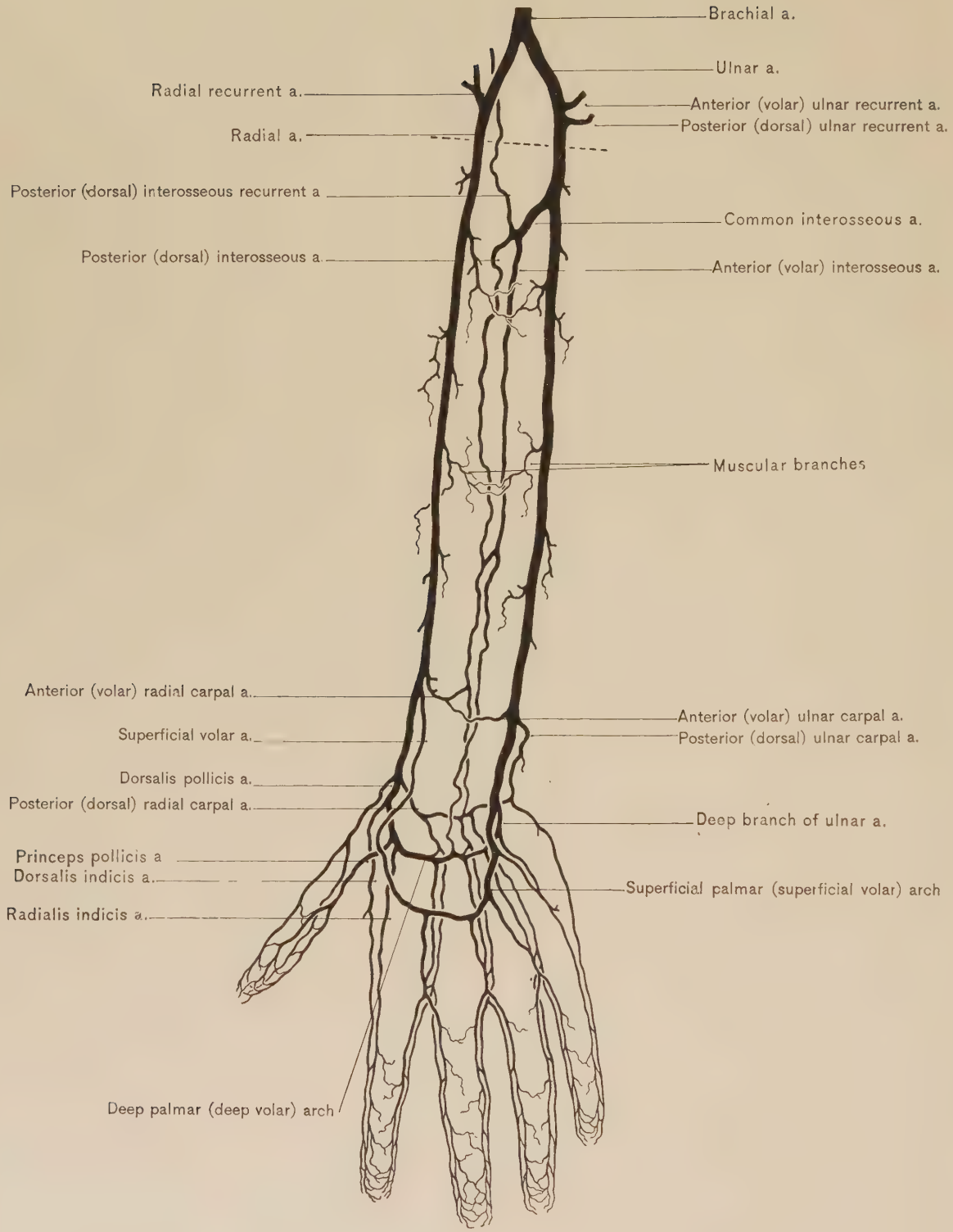
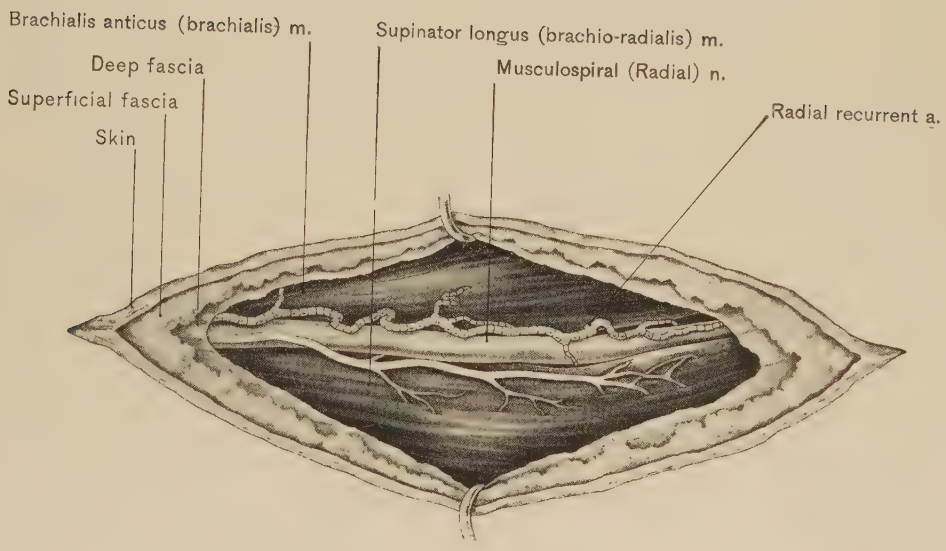
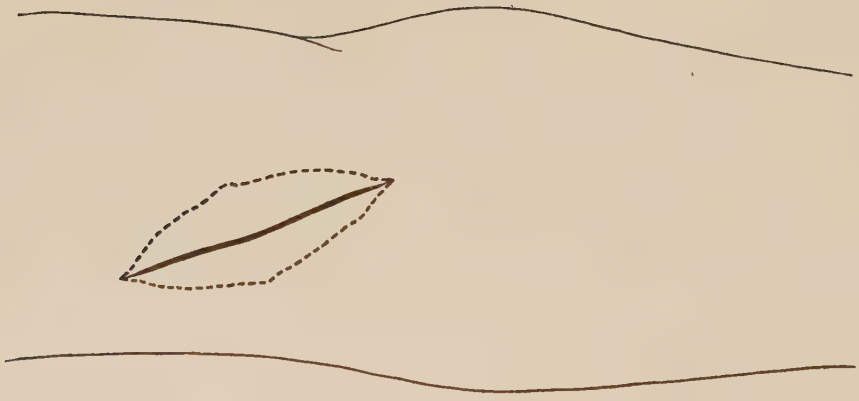


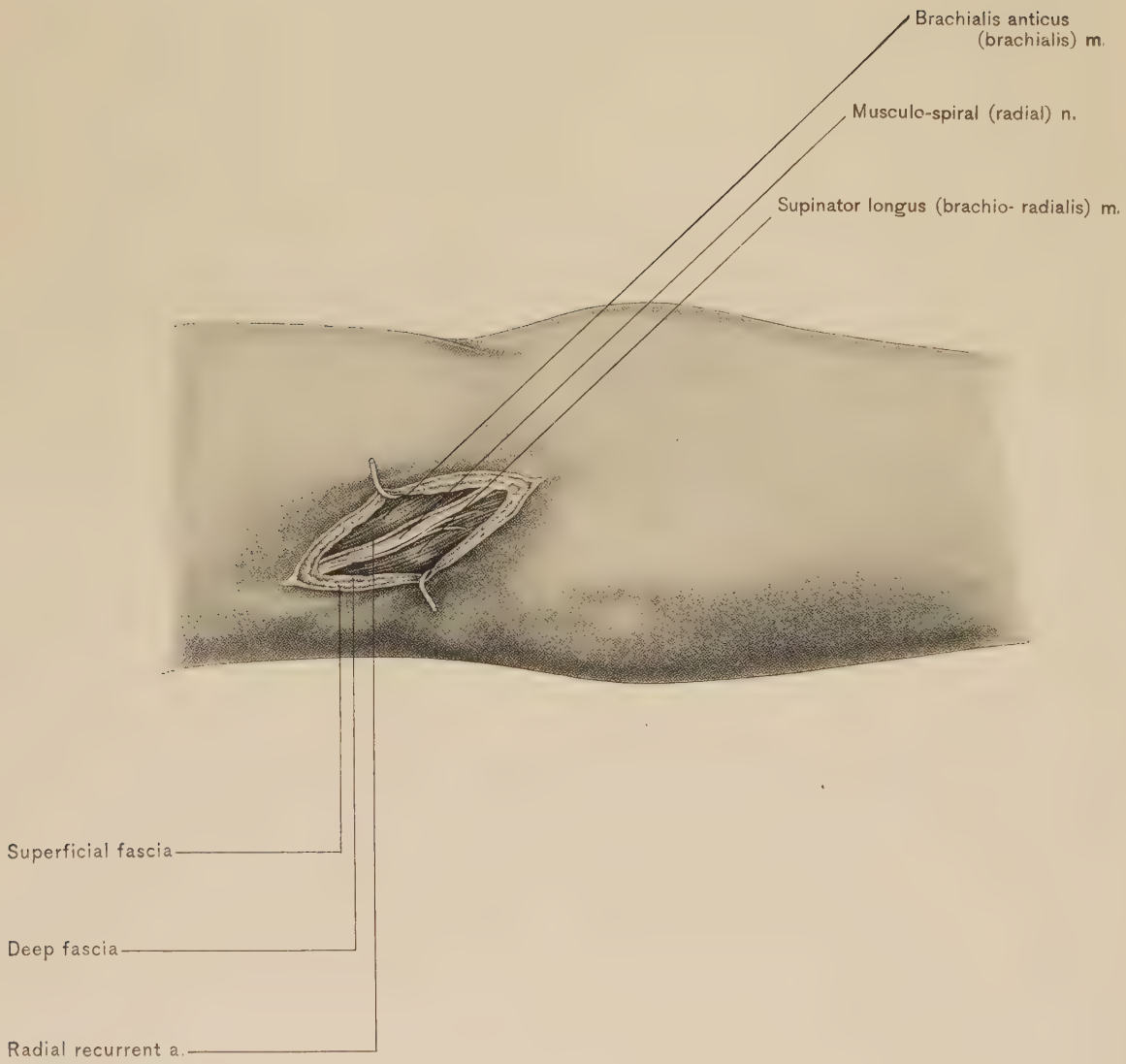
DIAGRAM OF COLLATERAL CIRCULATION AFTER LIGATION OF RADIAL AND ULNAR ARTERIES.

PLATE CCVI.

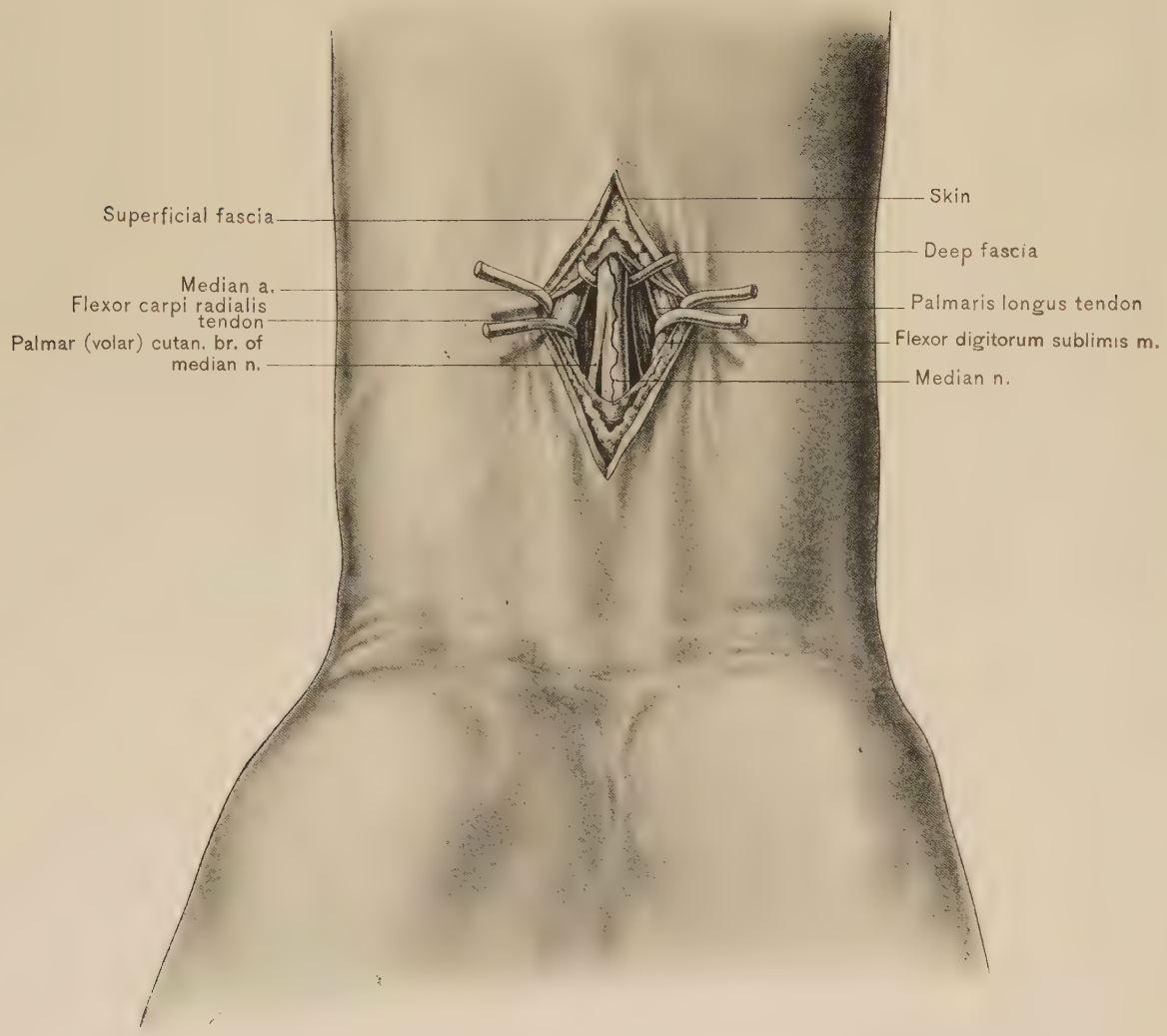




MUSCULO-SPIRAL (RADIAL) NERVE ABOVE LATERAL CONDYLE (EPICONDYLE) OF HUMERUS.



MUSCULO-SPIRAL (RADIAL) NERVE ABOVE LATERAL CONDYLE (EPICONDYLE) OF HUMERUS.



MEDIAN NERVE ABOVE WRIST.

PLATE CCIX.

SURFACE MARKS OF BACK.

The **ulnar artery** (Plates CCIII; CCIV) may be ligated either in the middle or the distal third of the forearm; it is seldom ligated in the proximal third because of the deep position of the artery there. The proximal portion of the ulnar artery describes a curve medialward, to the ulnar side of the forearm. Its lower two-thirds corresponds to a line drawn from a point midway between the medial condyle (*epicondyle*) of the humerus and the middle of the bend of the elbow to the radial side of the pisiform bone. The forearm should be supinated, and an incision made over the line of the vessel, just to the radial side of the tendon of the flexor carpi ulnaris. The deep fascia is exposed and incised and the tendon of the flexor carpi ulnaris brought into view. The tendon is drawn medialward, and the ulnar vessels exposed. The sheath of the vessels is generally bound to the flexor profundus muscle by a layer of fascia, which must be divided. The ulnar nerve will be found near the artery, on its ulnar side, and its palmar cutaneous branch in front of the vessel. Displace the ulnar nerve and its palmar cutaneous branch medialward; separate the venæ comites from the artery and pass the ligature from within outward.

The ulnar artery occasionally arises from the brachial artery high in the arm, or from the axillary artery. When it has a high origin, it usually passes over the muscles which spring from the medial condyle (*epicondyle*), and is, therefore, in danger of being wounded. Under these circumstances the recurrent and common interosseous branches arise from the continuation of the brachial artery.

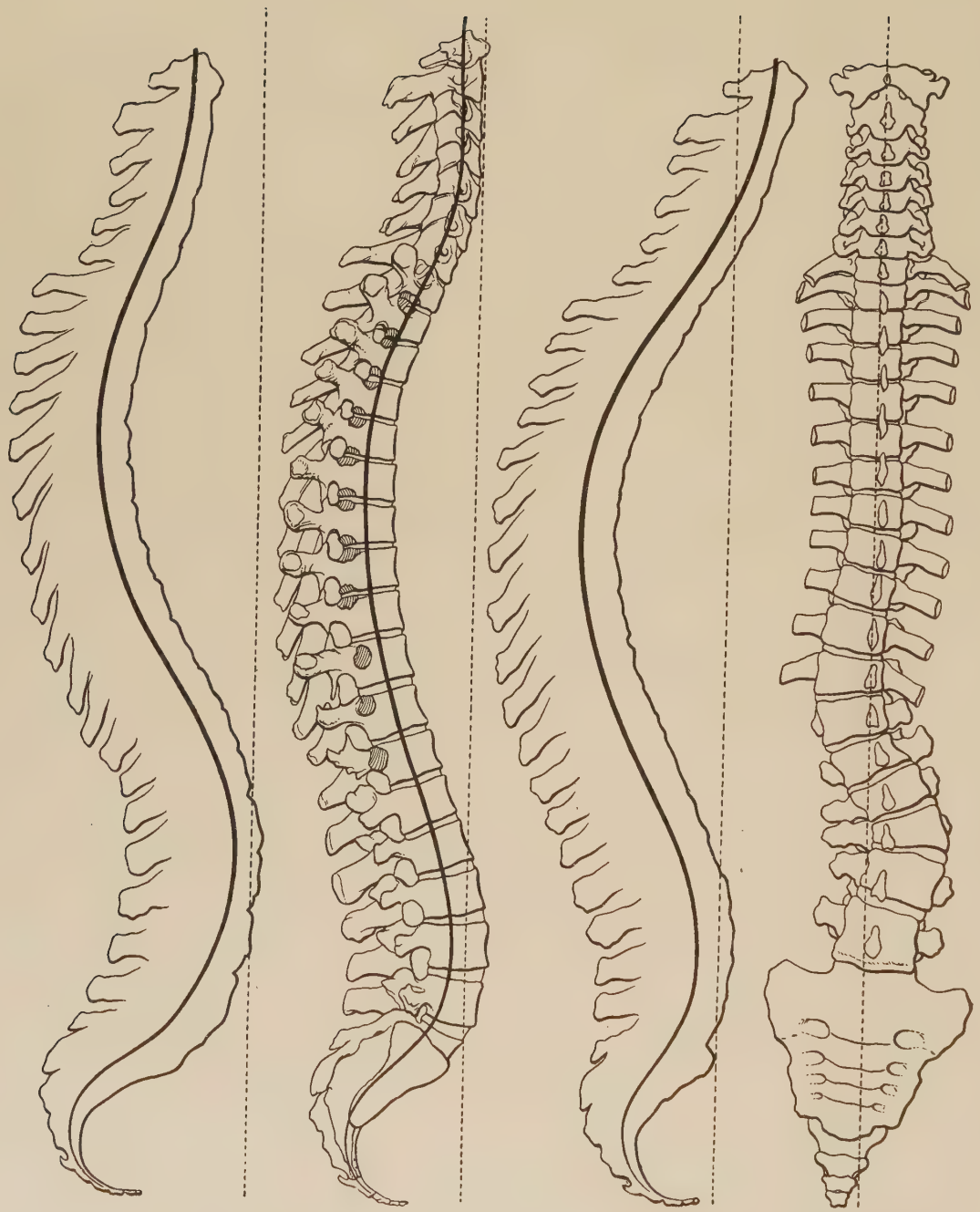
After ligating the radial or ulnar artery, the *collateral circulation* is chiefly established through the palmar (*volar*) and carpal arches, and partially through the anastomosis of the muscular branches of the two vessels (Plate CCV).

THE BACK OF THE NECK, SHOULDER, AND TRUNK

Surface anatomy (Plate CCIX).—In the median line, extending from the external occipital protuberance to the sacrum, is a longitudinal furrow, especially well pronounced in muscular subjects in the dorsal and lumbar regions, and which at the back of the neck is called the *nuchal*, and below that point the *spinal furrow*. It is produced by the presence of large muscle masses upon each side of the median line and by the close adherence of the fasciæ to the ligamentum nuchæ and the supraspinal ligaments. In the neck and in the dorsal region this groove lies between the trapezius muscles, and in the lumbar region between the erector spinæ (*sacro-spinalis*) muscles. In muscular subjects the two parts of the erector spinæ (*sacro-spinalis*) muscle are visible. The spinal furrow is deepest in the lower dorsal and the upper lumbar region; as it descends it becomes more shallow toward the sacrum, where the erector spinæ (*sacro-spinalis*) muscles are more tendinous. A depression a little above and lateral to the last spinous process of the sacrum (*third sacral spine*) marks the position of the posterior superior spine of the ilium; at the bottom of the nuchal furrow the bifid spine of the axis (*epistropheus*), the spines of the third, fourth, and fifth cervical vertebræ, can be somewhat indistinctly felt; while the spines of the sixth and seventh cervical and the first dorsal vertebræ stand out prominently. At the bottom of the spinal furrow the spinous processes of the dorsal and lumbar vertebræ may be readily distinguished, becoming more pronounced when the body is bent forward.

The **scapula** can be easily outlined at the back of the shoulder in thin persons but not so easily in obese persons. The vertebral border of the bone is felt at the side of the spinal furrow, and with the arm at the side of the body is parallel with the spinous processes of the vertebræ. During abduction of the arm, the inferior angle of the scapula glides forward and the vertebral border makes an increasing angle with the spinous processes of the vertebræ. The axillary border is indistinctly felt, while the superior border cannot be palpated through the overlying muscles. With the arms hanging at the sides, the superior (*medial*) angle of the scapula is opposite the upper margin of the second rib, and the inferior angle overlies the seventh intercostal space. The inferior angle is a guide in aspirating or draining the pleural sac, which is usually performed in the fifth or sixth intercostal space in the posterior axillary line. The spinous and acromion processes of the scapula are subcutaneous and readily palpated, so that fractures of these processes are detected more easily than fractures of other portions of the scapula. The root of the spine is marked by a depression at the upper vertebral border of the scapula, and is opposite the spinous process of the third thoracic vertebra. The lateral extremity joins the acromion process. The *acromial angle* is at the junction of the inferior margin of the spinous process with the lateral margin of

PLATE CCX.



Lordosis. Normal curve. Kyphosis. Scoliosis.

the acromion process. From this angle the length of the upper extremity can be measured, the distal points selected being the lateral condyle (*epicondyle*) of the humerus and the styloid process of the radius, or the medial condyle (*epicondyle*) of the humerus and the styloid process of the ulna.

Over the medial end of the spine of the scapula is a depression which marks the position of the flat, triangular tendon of insertion of the lower fibers of the trapezius muscle. Above the spine of this bone, extending to the sloping surface of the shoulder, is a rounded elevation, produced by the trapezius resting upon the levator scapulæ and supraspinatus muscles.

With the patient in a sitting position and his arms hanging between the thighs so as to depress the scapulæ, the spines of those bones are almost opposite the fissures between the superior and inferior lobes of the lungs. The location of these fissures is of importance in the localization of pneumonic lesions.

The lower ribs can be felt at the back of the trunk, lateral to the erector spinæ (*sacro-spinalis*) muscle. As the twelfth rib does not always extend beyond the lateral margin of the erector spinæ (*sacro-spinalis*) muscle, the ribs should be counted from above downward. Just below the last rib and in the depression lateral to the erector spinæ (*sacro-spinalis*) muscle the kidney can be palpated and subjected to pressure. It is through this depression that the right kidney can be exposed, since there is a distance of about six and one quarter centimeters (two and one half inches) between the twelfth rib and the crest of the ilium. The middle of the iliac crest is the location of Petit's (*lumbar*) triangle.

In percussion or auscultation at the back of the chest, the patient should cross his arms and lean forward so that the scapulæ will be carried forward and uncover as much of the posterior surface of the chest as possible.

The **spines of the vertebræ** should lie in a straight line, and the spinal column present no lateral curves. The back, like the spinal column, contains four anteroposterior curves: cervical, thoracic, lumbar, and pelvic. The cervical curve of the spinal column is convex forward, the thoracic concave forward, the lumbar convex forward, and the pelvic, which is formed by the sacrum and the coccyx, concave forward. As seen in viewing the surface of the back, the cervical curve is concave backward, the thoracic convex backward, the lumbar concave backward, and the pelvic convex backward.

Disease, overwork, bad posture, injury, and senility may alter the curves of the spinal column. The weight of the head falls on the condyles of the occiput. A perpendicular line through the condyles passes through the points where the vertebral curves pass into each other and then through the anterior edge of the sacral promontory. Therefore, if one vertebral curve is altered it must be compensated for by a corresponding alteration in the curve on the opposite side of the perpendicular line.

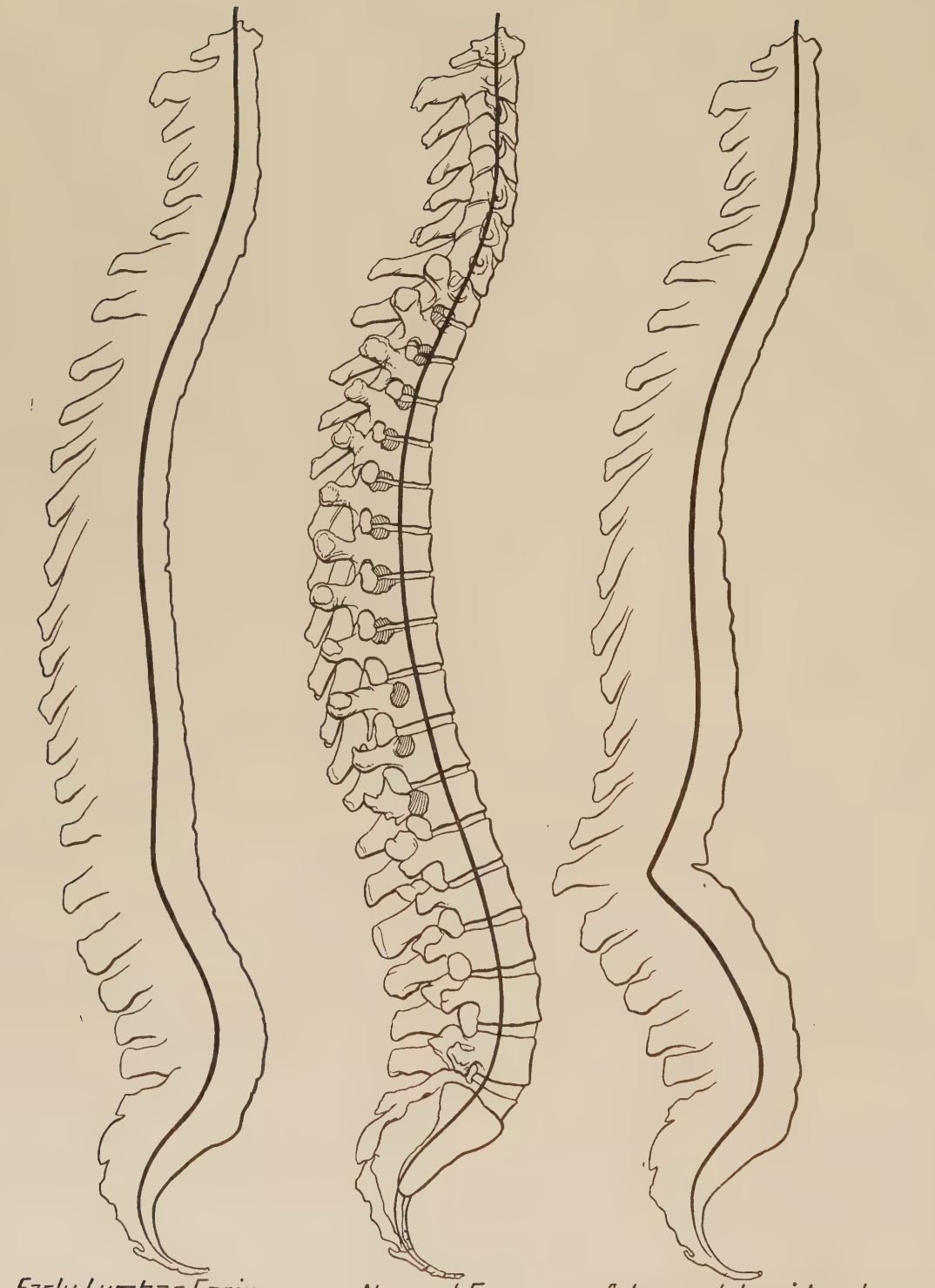
Kyphosis, (Plate CCX), or forward curvature of the spine, is seen in rachitic children, in children with Pott's disease, in old persons, and in laborers who do heavy work. The vertebra are supported by the articular processes and by the bodies separated by the intervertebral discs, the latter being the most important. In rickets the bones contain less calcium than in health, and become so abnormally flexible that the weight of the head bends the spinal column forward. In old persons and in laborers the forward curvature is caused by thinning or compression of the intervertebral discs. In tuberculous disease of the bodies of the vertebræ an angular kyphosis develops.

In **lordosis** the lumbar curve, which develops when a child begins to walk, is exaggerated, and the depression in the lumbar region of the back is increased. This condition is seen in persons who, in order to retain their equilibrium, are compelled to throw the shoulders backward, as in individuals with congenital luxation of the hip, or when spinal caries has caused angular forward curvature of the upper part of the thoracic region of the spine, thus increasing the curve of the lumbar spine on account of the advanced position of the head and shoulders; also in pregnant women and in obese persons.

Scoliosis, or lateral curvature of the spinal column, in children is caused by sitting in an incorrect position for a long time; by unequal length of the lower extremities, most commonly the result of hip-joint disease, and by empyema. It is not a simple lateral bending, but a lateral rotation. In hip disease, nature tilts the pelvis to compensate for the shortness of the affected limb, and curves the spinal column laterally so that equilibrium may be maintained. In empyema when one lung is permanently collapsed, the pulmonary space of that side is diminished, the ribs fall together, and the thoracic portion of the spinal column is curved. Curvature of the thoracic portion necessitates compensatory curvature of the lumbar portion of the spinal column. The concavity of the thoracic and the convexity of the lumbar curvatures are directed toward the affected side. In the most common form of lateral curvature the thoracic region of the spinal column is deflected to the right and the lumbar region to the left. A line drawn along the tips of the spines of the vertebræ would be more curved than one that passes through the centers of the bodies of the vertebræ, the difference being due to rotation of the vertebræ, so that the tips of the spines extend still farther in the direction of the convexity of the curve. When the lateral curve of the thoracic region of the spinal column is convex to the right, the right shoulder is elevated and the left shoulder depressed, and vice versa.

Angular curvature of the spinal column is produced by caries of the vertebræ. In this disease the bodies of some of the adjacent vertebræ are more or less disintegrated by tuberculous ulceration, the laminæ and processes remaining unaffected. Removal or softening of the bodies of the vertebræ allows the super-

PLATE CCXI.

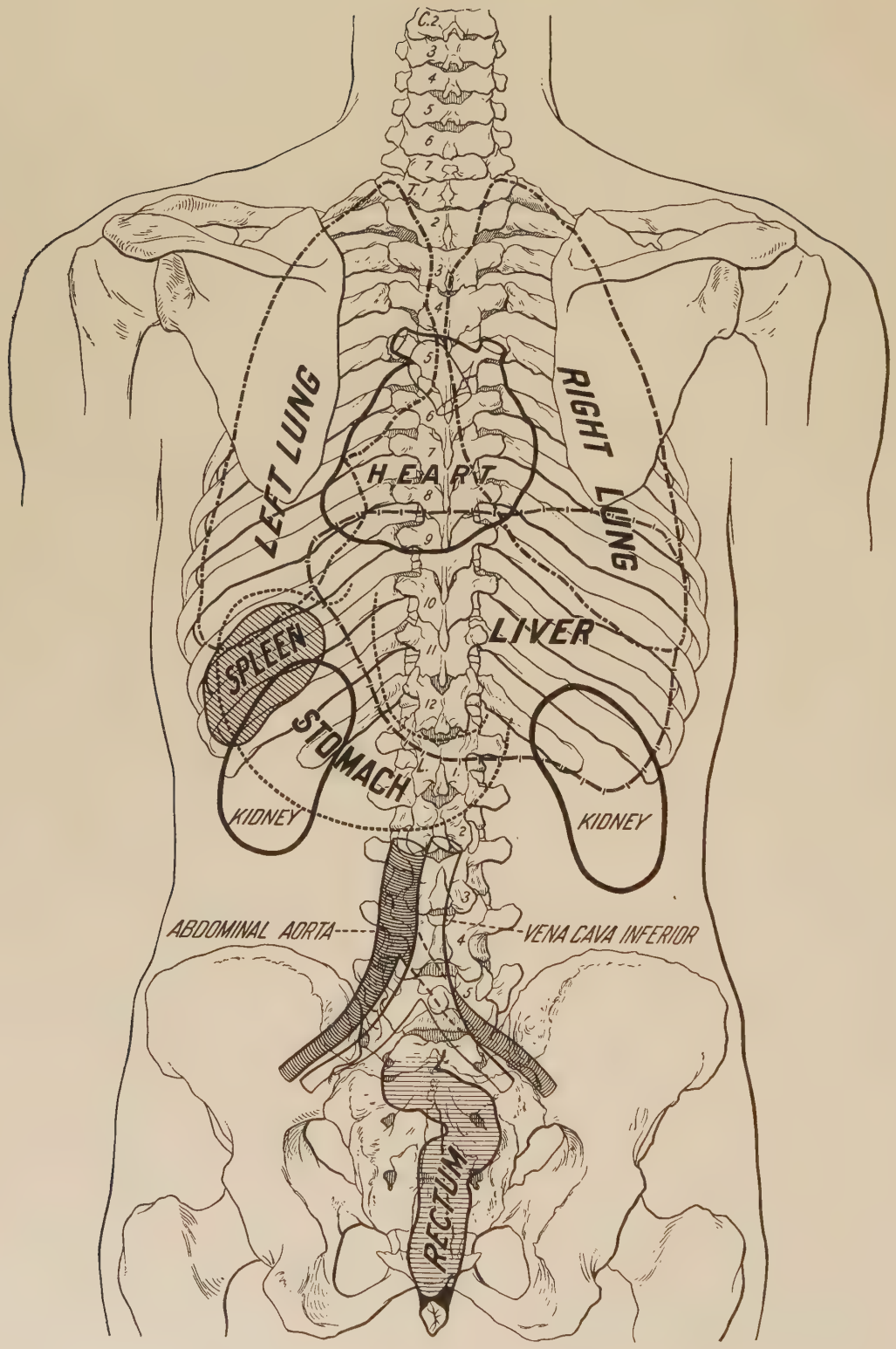


Early Lumbar Caries
Normal Curve Effaced

Normal Curve

Advanced dorsi-Lumbar
Caries; Angular Curvature

PLATE CCXII.



RELATION OF VISCERA OF THORAX AND ABDOMEN TO THE VERTEBRAL SPINES.

imposed weight to compress the bodies; and as the vertebral arches are not compressible, the affected portion of the spinal column is sharply curved forward and the spinous processes of the involved vertebræ project backward. This is a definite indication of spinal caries, or Pott's disease.

Abscess formation resulting from rapidly progressing tuberculous caries of the vertebræ is not associated with heat and redness (cold abscess).

In **disease of the cervical vertebræ** the pus accumulates behind the prevertebral fascia and the pharynx, forming a retropharyngeal abscess, which causes bulging in the posterior pharyngeal wall and difficulty in respiration and deglutition. It may rupture into the pharynx, gravitate to the posterior mediastinum, or burrow outward to the posterior triangle of the neck, and even enter the axilla.

In **caries of the dorsal vertebræ** the pus usually gravitates to the diaphragm, passes under the internal arcuate ligament (*medial lumbo-costal arch*) and the psoas fascia, and forms a **psoas abscess**; or it burrows under the external arcuate ligament (*lateral lumbo-costal arch*) and the anterior lamella of the lumbar (*lumbo-dorsal*) fascia, and forms a **lumbar abscess.** The pus may, however, ulcerate backward between the ribs, and cause a swelling in the back; or it may follow the ribs and intercostal muscles forward and produce a swelling at the side or the front of the chest. These abscesses occasionally rupture into the esophagus, pleura, lung, or pericardium, but this is rare.

In **caries of the lumbar vertebræ** (Plate CCXI) the pus usually enters the sheath of the psoas muscle, which is formed by the prevertebral fascia, and forms a **psoas abscess.** It gravitates downward under the psoas division of the iliac fascia. After passing under Poupart's (*inguinal*) ligament it produces a swelling at the lateral side of the femoral sheath, where the psoas and the iliacus muscles approach the surface from a common tendon, and occupy a common fascial compartment. If the abscess burrows down further and perforates through the sheath of the tendon, it may present to the medial side of the vessels, since the iliopsoas muscle inserts in the lesser trochanter of the femur. These abscesses may also ulcerate through the iliac fascia and open into the peritoneal cavity, the ascending or descending colon, or other portions of the bowel, the ureter, or the bladder. The pus may also pass through the great sacro-sciatic (*greater sciatic*) notch and point on the posterior surface of the thigh. Sometimes it passes under the anterior lamella of the lumbar fascia into the sheath of the quadratus lumborum muscle, and forms a **lumbar abscess.** This abscess may ulcerate through the middle and posterior lamellæ of the lumbar (*lumbo-dorsal*) fascia and into the triangle of Petit (*lumbar triangle*), and produce a swelling near the middle of the crest of the ilium.

Spina bifida is the result of failure of the laminæ of the vertebra to unite. The union normally begins at the dorsal (*thoracic*) region and extends upwards

and downwards. Through the bony defect a dural sac usually protrudes which may or may not contain nervous elements. The parts below are frequently paralyzed and hydrocephalus at times coexists.

The **spines of the vertebræ** may be used as landmarks in locating various thoracic and abdominal structures (Plate CCXII). It should be remembered, however, that the tips of the spinous processes in the thoracic region, with the exception of the eleventh and twelfth, are not opposite the bodies of the corresponding vertebræ.

The *fourth cervical spine* corresponds to the opening of the larynx, and the point of origin of the external and internal carotid arteries at the bifurcation of the common carotid artery.

The *sixth cervical spine* is situated opposite the cricoid cartilage and the commencement of the esophagus.

The *seventh cervical spine* which with its vertebra is called the vertebra prominens, corresponds to the highest level of the apices of the lungs and to the summit of the arch of the subclavian artery.

The *third thoracic spine* lies opposite the point where the aorta approaches the spinal column, the upper level of the lower lobes of the lungs and the bifurcation of the trachea.

The *fourth thoracic spine* is located opposite the point of termination of the arch of the aorta and the upper level of the heart.

The *seventh thoracic spine* is on a level with the lower angle of the scapula.

The *eighth thoracic spine* marks the lower level of the heart and the level of the central tendon of the diaphragm.

The *ninth thoracic spine* marks the level of the cardiac orifice of the stomach and the upper limit of the spleen.

The third to the ninth thoracic spines correspond to the heads of the fourth to the tenth ribs, respectively.

The *tenth thoracic spine* marks the lower level of the bases of the lungs and the level at which the liver reaches the abdominal walls, posteriorly.

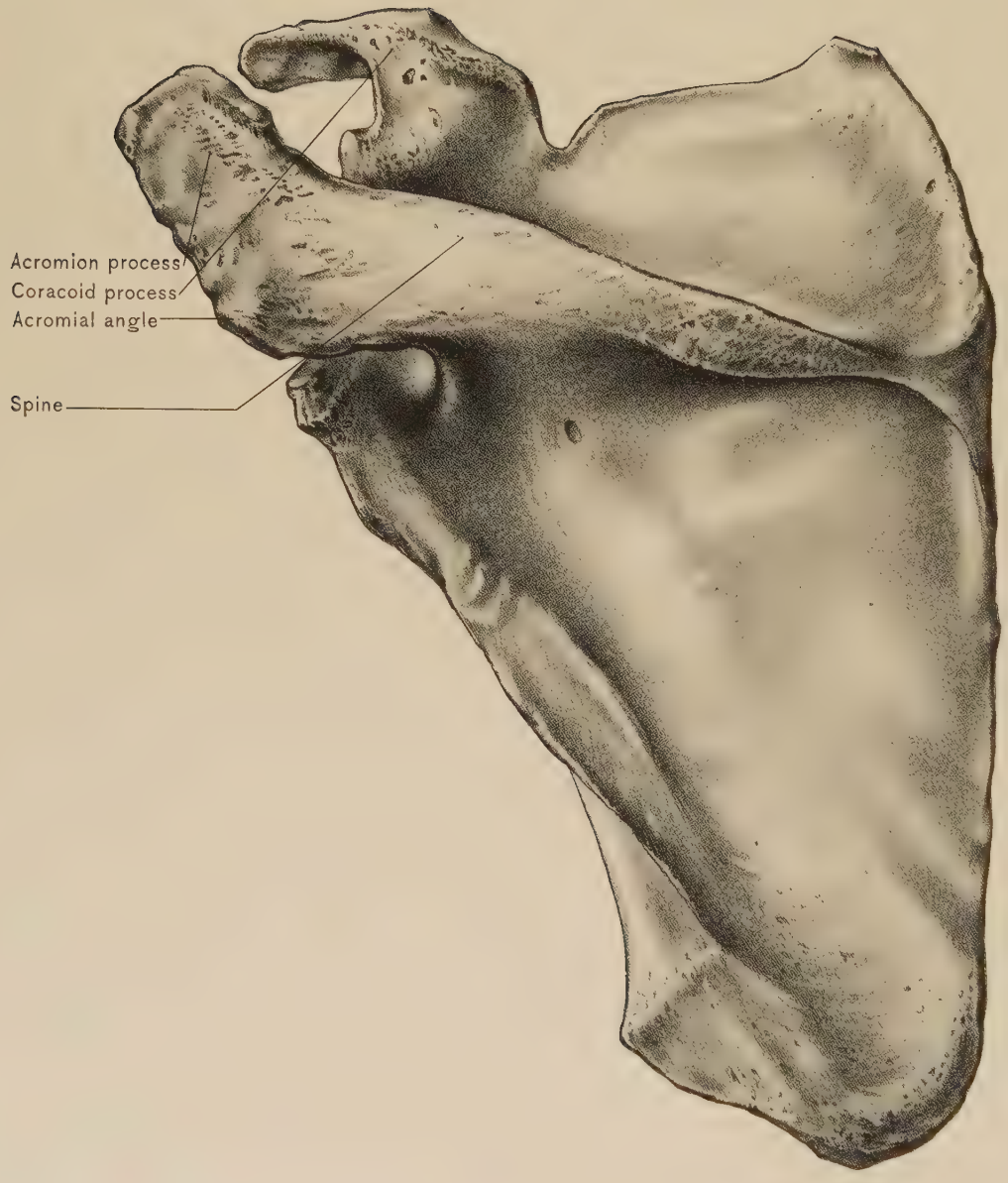
The *eleventh thoracic spine* marks the lower limit of the spleen, the position of the suprarenal capsule, and the upper border of the right kidney.

The *twelfth thoracic spine* is on a level with the lower limit of the pleura, the aortic opening of the diaphragm and the pylorus, and with the head of the last rib.

The *first lumbar spine* is situated opposite the renal vessels, the renal pelvis, and the pancreas.

The *second lumbar spine* lies opposite the end of the spinal cord, and the beginning of the cauda equina; it also corresponds to the second portion of the duodenum, the opening of the common bile duct into the duodenum, the lower margin

PLATE CCXIII.



DORSUM OF SCAPULA SHOWING ACROMIAL ANGLE.

of the kidney and of the pancreas, the origin of the superior mesenteric artery, the portal vein, and the upper end of the receptaculum chyli.

The *third lumbar spine* is found just above the level of the umbilicus and below the lower border of the right kidney, and opposite the origin of the inferior mesenteric artery.

The *fourth lumbar spine* is located opposite the bifurcation of the aorta and the highest part of the crests of the ilia.

The *fifth lumbar spine* is slightly below the origin of the inferior vena cava.

The *third sacral spine* lies opposite the termination of the sigmoid flexure and the lowest level of the spinal membranes.

The *tip of the coccyx* marks the junction of the first and second portions of the rectum.

The **spinal origins of the spinal nerves** are not opposite their correspondingly numbered vertebræ, but will be found as follows: the *eight cervical nerves* arise above the sixth cervical spine, the *upper six thoracic nerves* between the sixth cervical and fourth thoracic spines, the *lower six thoracic nerves* between the fourth and eleventh thoracic spines, the *five lumbar nerves* between the eleventh and twelfth thoracic spines, and the *five sacral nerves* and the *coccygeal nerve* between the last thoracic and the first lumbar spines.

The **positions of the primary bronchi** are indicated by lines extending from the third thoracic spine, or a point a little below it, to the dimple in the skin over the root of the spine of the scapula. Sounds are heard more clearly in the right bronchus because it lies nearer the back of the chest.

The **kidneys** are situated opposite the two lower ribs, with their inferior poles projecting below the twelfth rib, the right being somewhat lower than the left. Tenderness in the diseased organ, if present, can be elicited by making pressure upon it just under the last rib, lateral to the erector spinæ (*sacro-spinalis*) muscle. This is also the site of incision for operations on the kidney by the lumbar route.

The **iliac crest** at its highest point is located about opposite the fourth lumbar spine.

The external surface of the **spleen** is directed lateralward and posteriorly in an oblique position, its long axis almost corresponding to the line of the tenth rib. It lies beneath the ninth, tenth, and eleventh ribs, from which it is separated by the peritoneum, the diaphragm, the inferior portion of the left lung, and the two layers of the left pleura.

To each side of the spinal furrow in the upper part of the back are the **scapulæ,** or shoulder blades, covered by the trapezius, deltoid, supraspinatus, infraspinatus, and latissimus dorsi muscles. The scapulæ cover the ribs from the second to the seventh inclusive. The parts of the scapula most readily felt are the spine

and the acromion process, both of which are subcutaneous. The position of the acromion is marked by a depression when the arm is elevated, and in muscular subjects with the arm hanging loosely.

At the junction of the lateral border of the acromion with the inferior border of the spine is found the **acromial angle** (Plate CCXIII), the point from which measurements are taken to determine the comparative lengths of the upper extremities. At the medial end of the spine of the scapula is a depression which corresponds to the triangular tendon into which the inferior fibers of the trapezius muscle are inserted.

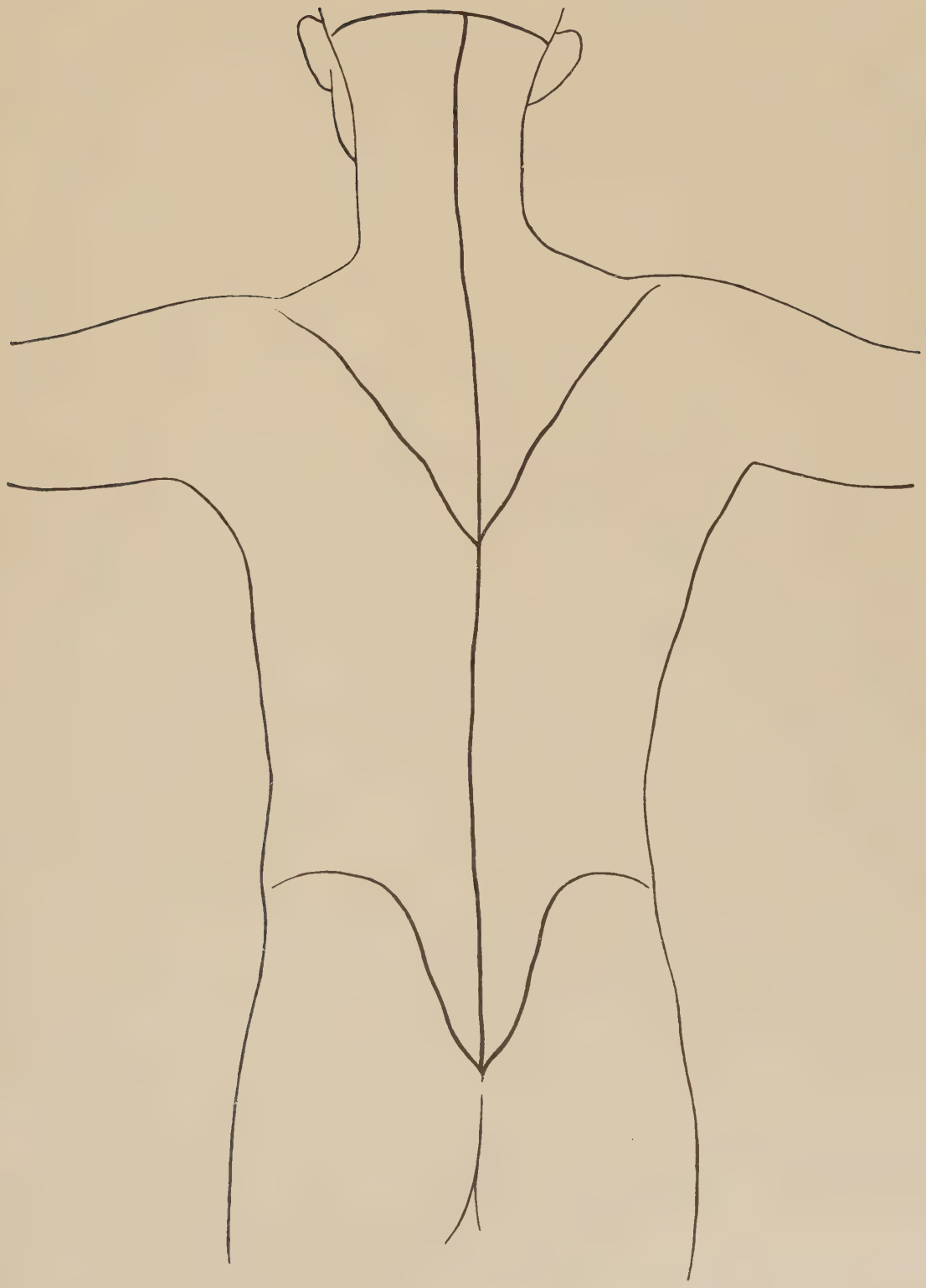
The sloping superior surface of the **shoulder** is formed by the trapezius which covers the supraspinatus and levator anguli scapulæ (*levator scapulæ*) muscles.

The *inferior angle of the scapula* lies opposite the seventh intercostal space, thus serving as a landmark in locating the seventh rib. This angle is covered by the latissimus dorsi muscle, which assists in holding the bone against the chest wall. Projection of the angle and of the vertebral border of the bone results from atrophy of the muscle covering it and of the serratus magnus (*serratus anterior*) and leads to a deformity known as "winged scapula," (see p. 204). The *vertebral border* of the scapula can be traced upward from the inferior angle, and with the arm hanging at the side of the body is nearly parallel to the spinal furrow. At the upper extremity of this border the *superior (medial) angle* of the scapula can be distinguished, which, with the arm at the side of the body is opposite the superior border of the second rib and on a level with the interval between the spines of the first and second thoracic vertebræ. The *superior border* of the scapula can seldom be felt, on account of the thickness of the overlying muscle, and its *axillary border* is only indistinctly felt through its thick muscular covering.

The *movements* of the scapula are a gliding upward and downward motion, as in shrugging the shoulders, backward and forward, as in moving the shoulders back and forth, and a gliding rotatory motion, as when the arm is fully abducted. These movements are best studied in the living subject. On account of the great mobility of the scapula, ankylosis of the shoulder-joint does not occasion so much disability as might be expected.

Dissection (Plate CCXIV).—Place the body, face downward upon the table, with a block under the chest and one under the pelvis so as to curve the back and permit the head to hang low enough to make the structures of the back tense. The arms should be allowed to hang over the sides of the table to make the structures between the shoulders tense. Carry an incision from the external occipital protuberance down the median line of the back to the sacrum. From the upper end of this incision make another laterally over the superior curved line of the occipital bone. Make a third incision from the acromion over the spine

PLATE CCXIV.



INCISIONS FOR DISSECTION.

of the scapula to the first incision, and, lastly, one from the lower end of the longitudinal cut, along the sacro-iliac junction and over the crest of the ilium. Reflect the segments of skin lateralward, and expose the superficial fascia with its vessels and nerves, all of which are small.

In the back of the neck and upper part of the back the **arteries and nerves** appear at the side of the vertebral spines near the median line of the back and extend mainly lateralward. The arterial blood of the back of the neck is derived from the occipital, the princeps cervicis (*descending branch of occipital*), the posterior scapular (*descending branch of transverse cervical*), and the superficial cervical (*ascending branch of transverse cervical*) arteries; of the back of the shoulder and upper part of the back from the posterior scapular (*descending branch of transverse cervical*), suprascapular (*transverse scapular*), dorsalis scapulæ (*circumflex scapular*), and intercostal arteries, and of the middle and lower part of the back from the posterior, or dorsal, branches of the intercostal and lumbar arteries. Branches of the posterior primary divisions of the spinal nerves furnish the nerve supply.

Each spinal nerve arises from the spinal cord by two roots, an anterior, or ventral (efferent, or motor) root, and a posterior, or dorsal (afferent, or sensory), root. The common trunk, formed by the union of the anterior and posterior roots, as it emerges from its intervertebral foramen gives off a meningeal, or recurrent, branch after which it divides into two branches, the anterior and posterior primary divisions (*rami*).

The **posterior primary branches (posterior rami) of the spinal nerves,** with the exception of the first cervical (*suboccipital*), the fourth and fifth sacral, and the coccygeal nerves, divide into lateral and medial branches which supply the muscles of the back. Each primary branch supplies sensory fibers to the skin in each region of the back.

Accordingly, the lateral branches in the *cervical region* supply the muscles, while the medial branches of the second, third, fourth, and fifth nerves supply the skin, fasciæ, and muscles. The medial branch of the posterior division of the second cervical nerve, known as the **greater occipital,** pierces the complexus (*semispinalis capitis*) and trapezius muscles and ramifies with the occipital artery in the superficial fascia of the back of the scalp, being the main sensory nerve to the posterior half of the scalp. The medial branches of the third, fourth, and fifth cervical nerves, after supplying the adjacent muscles, pierce the trapezius muscle near the ligamentum nuchæ and pass lateralward to supply the skin and fasciæ over that muscle. The medial branch of the third cervical nerve is directed toward the scalp, and is called the **least, or third, occipital nerve.** The branches of the sixth, seventh, and eighth cervical nerves supply the adjacent muscles.

In the *thoracic region* the lateral branches of the posterior divisions of the upper six thoracic nerves supply the muscles, while the same branches of the

lower six, after supplying the muscles, pierce the latissimus dorsi near the angles of the ribs to supply the skin. The medial branches of the posterior divisions of the upper six thoracic nerves supply the muscles of the back, and pierce the trapezius near the spinous processes to supply the skin. The medial branches of the lower six thoracic nerves supply the muscles, and send small twigs to the skin.

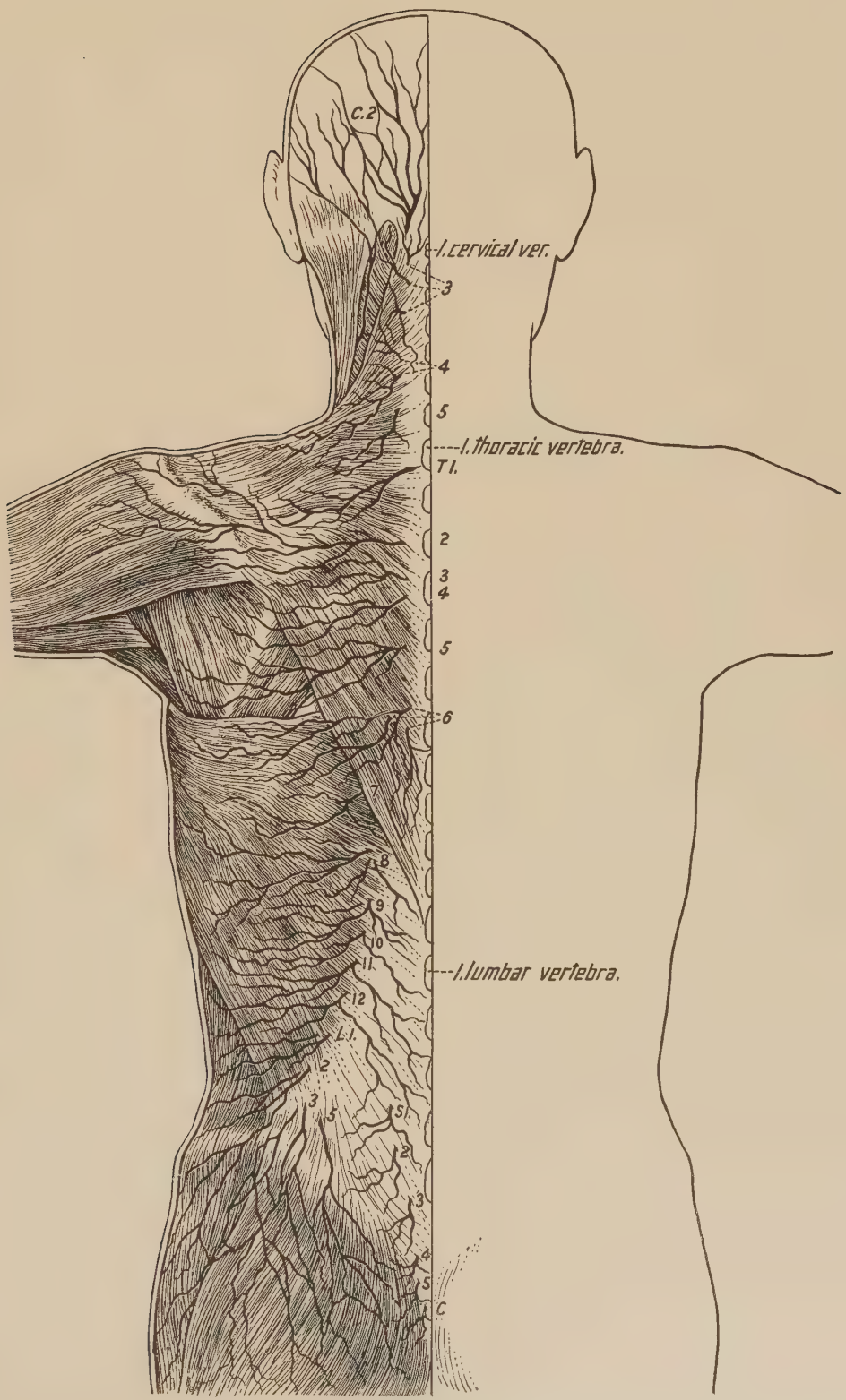
The lateral branches of the posterior divisions of the first three lumbar nerves supply the adjacent muscles, become subcutaneous at the lateral border of the erector spinæ (*sacro-spinalis*), and pass over the crest of the ilium to supply the skin of the gluteal region; the corresponding branches of the fourth and fifth lumbar nerves supply the erector spinæ (*sacro-spinalis*) muscle. The *medial branches* of the posterior divisions of the lumbar nerves are small; they supply the multifidus muscle.

The posterior primary divisions (*posterior rami*) of the upper four *sacral nerves* emerge at the posterior sacral foramina, while the posterior division of the fifth emerges with the dorsal division of the coccygeal nerve through the lower end of the sacral canal.

The posterior divisions of the upper three *sacral nerves* divide into lateral and medial branches, while the lower two sacral and the coccygeal nerves do not divide. The lateral branches of the posterior divisions of the upper *three sacral nerves* form a series of loops, or plexiform communications, upon the back of the sacrum, between themselves and the lateral branch of the last lumbar nerve, and a secondary series upon the posterior surface of the great sacro-sciatic (*sacro-tuberous*) ligament. Two or three nerves derived from these loops pierce the gluteus maximus to supply the integument. The medial branches of the posterior divisions of the upper three sacral nerves supply the multifidus muscle. The posterior divisions of the lower two sacral nerves, unlike the other sacral nerves, do not divide into two branches. They unite with each other and with the coccygeal nerve in loops to form the *posterior sacro-coccygeal nerve*, branches of which supply the skin over the coccyx.

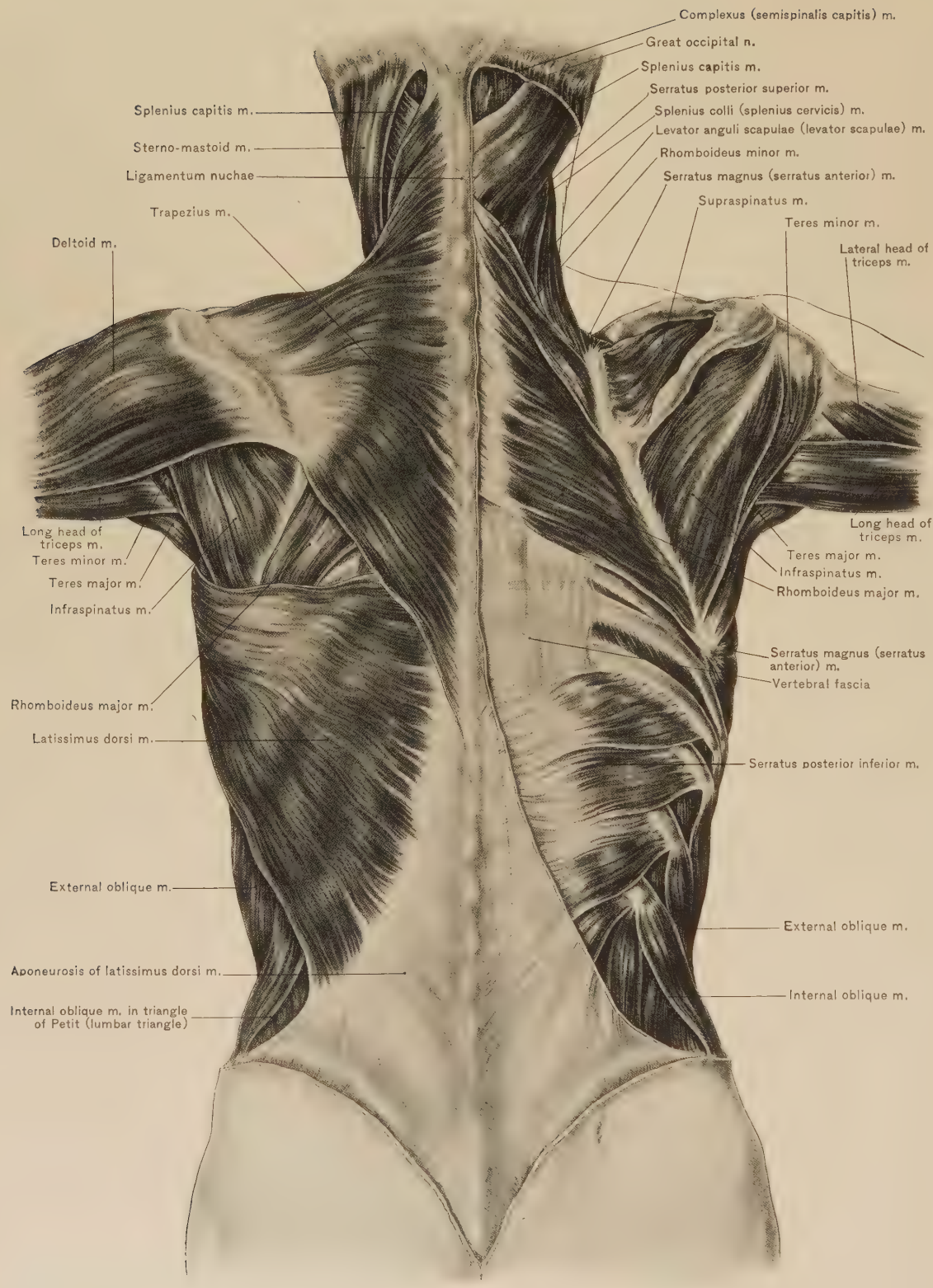
Cutaneous nerves (Plate CCXV).—The skin of the back is supplied in a regular, segmental manner: in the *cervical region*, by the medial branches of the posterior divisions of the second, third, fourth, and fifth cervical nerves; in the *thoracic region*, by the medial branches of the posterior divisions of the upper six thoracic nerves, and the medial and lateral branches of the posterior divisions of the lower six thoracic nerves; in the *lumbar region*, by the lateral branches of the posterior divisions of the upper three lumbar nerves; over the *sacrum* and *coccyx*, by the lateral branches of the posterior divisions of the last lumbar nerve and the upper three sacral nerves, the posterior divisions of the lower two sacral nerves, and the coccygeal nerve.

PLATE CCXV.



CUTANEOUS NERVES OF BACK.

PLATE CCXVI.



MUSCLES OF BACK.

The cutaneous nerves are accompanied by the cutaneous branches of the dorsal branches of the intercostal and lumbar arteries.

DISSECTION.—The superficial fascia is reflected after making incisions similar to those made in the removal of the skin.

The **deep fascia,** dense and fibrous, invests the superficial muscles of the back (trapezius and latissimus dorsi). It is continuous with all the adjacent deep fasciæ, and is attached to the following bony prominences of the back: the spines of the vertebræ with the intervening supraspinal ligaments, the sacrum, the iliac crests, the spines of the scapulæ, and the superior curved ridges (*superior nuchal lines*) of the occipital bone. In the lumbar region the deep fascia blends with the glistening triangular aponeurosis of the latissimus dorsi muscle, which extends from the iliac crest and sacrum as high as the spine of the seventh thoracic vertebra. This aponeurosis should be preserved, as it constitutes the superficial, or posterior, layer of the lumbar (*lumbo-dorsal*) fascia. The aponeurosis of the latissimus dorsi muscle is pierced at the lateral border of the erector spinæ (*sacro-spinalis*) muscle by cutaneous branches of the posterior divisions of the lumbar nerves.

DISSECTION.—The superficial layer of the deep fascia is reflected after making incisions similar to those made in removing the skin and superficial fascia. This exposes, in the neck, the trapezius muscle, with the occipital triangle, and the sterno-mastoid muscle on its lateral side; at the level of the shoulders, the trapezius muscle, the spine of the scapula, the deltoid and teres major muscles, the infraspinous fascia which covers the infraspinatus and teres minor muscles; below the level of the shoulders, the inferior part of the trapezius muscle, the latissimus dorsi and its aponeurosis, and the posterior fibers of the external and internal oblique muscles (Plate CCXVI).

The **trapezius,** one of the most extensive muscles of the body, is a broad, flat, triangular muscle, with the base of the triangle directed toward the spines of the vertebræ and the apex toward the summit of the shoulder. It *arises* from the medial third of the superior curved (*superior nuchal*) line of the occipital bone, the external occipital protuberance, the ligamentum nuchæ, the spinous process of the seventh cervical vertebra (vertebra prominens), the spinous processes of all the thoracic or dorsal vertebræ, and their supraspinal ligaments. From this extensive origin its fibers converge lateralward to the top of the shoulder. It is *inserted* into the contiguous margins of the clavicle, the acromion process, and the spine of the scapula, being attached to the lateral third of the posterior border and superior surface of the clavicle, to the medial border of the superior surface of the acromion process, and to the entire length of the superior margin of the spine of the scapula. Its inferior fibers form a triangular aponeurosis at the base of the spine of the scapula, over which it glides to be

inserted into a tubercle at the medial extremity of the spine. Between the base of the spine of the scapula and the tendon is a small synovial bursa, which facilitates the movements of the tendon. The muscle is tendinous at its attachments, and is adherent to the skin in the occipital region, while between the sixth cervical and third thoracic spines the aponeurosis of origin is semi-elliptical, forming a complete ellipse with its fellow of the opposite side (speculum rhomboideum). The two trapezii form a diamond-shaped quadrangle, a trapezium (hence the name), with the lateral angles at the shoulders and the vertical angles at the occiput and the twelfth dorsal spine.

The trapezius muscle is subcutaneous throughout its entire extent; in the neck it rests upon the complexus (*semispinalis capitis*), splenius capitis, splenius colli (*splenius cervicis*), levator anguli scapulæ (*levator scapulæ*), and rhomboideus minor muscles; and in the back upon the rhomboideus major, supraspinatus, infraspinatus, part of the serratus posterior superior, latissimus dorsi muscles, and the vertebral aponeurosis. Its anterior cervical border forms the posterior boundary of the posterior common triangle of the neck, and is nearly parallel with the posterior fibers of the sterno-mastoid muscle.

Blood Supply.—From the princeps cervicis (*descending branch of occipital*), superficial cervical (*ascending branch of transverse cervical*), posterior scapular (*descending branch of transverse cervical*) arteries, and the dorsal branches of the intercostal arteries.

Nerve Supply.—From the subtrapezial plexus which is formed by the spinal accessory (*accessory*) nerve and the deep branches of the cervical plexus which enter the muscle beneath its anterior margin near the clavicle.

Action.—The superior fibers elevate the lateral end of the clavicle and the point of the shoulder; acting from their insertion they rotate the head, draw it to the same side, and extend the neck. The middle fibers draw the scapula toward the spines of the vertebræ, and rotate it so as to raise the point of the shoulder. The inferior fibers draw the shoulder-blade medialward and downward, and rotate it so as to elevate the point of the shoulder. Acting as a whole, the two muscles draw the scapulæ nearer together, elevate the point of the shoulder, and extend the neck, as in opisthotonos.

The **ligamentum nuchæ,** a fibro-elastic band extending from the external occipital protuberance to the spine of the seventh cervical vertebra, is practically a continuation of the supraspinal ligaments of the dorsal vertebra. Fibrous extensions from it to the underlying spines of the cervical vertebræ, except the atlas, form a septum between the muscles of the two sides of the back of the neck. It is almost rudimentary in man, but in the living body can be demonstrated through the skin by dropping the head forward and allowing it to hang by its own weight. In the lower animals, such as the horse, the ligamentum nuchæ

holds the head up without any effort, in fact, muscular force is required to carry the head to the ground and hold it there, as in grazing.

The **latissimus dorsi** is a broad, flat, triangular muscle, with an elongated and twisted apex. It lies upon the lower portion of the back and the lateral side of the chest, covering a part of the side of the latter structure and all of the back from the level of the sixth thoracic vertebra to the crest of the ilium.

This muscle *arises* by an aponeurosis from the spinous processes of the lower six thoracic, the lumbar, and the sacral vertebræ, the intervening supraspinal ligaments, the back of the sacrum, and the posterior third of the external lip of the crest of the ilium, and from the lower three or four ribs by fleshy, finger-like bands which interdigitate with similar processes of the external oblique muscle. Its sacral origin is in common with that of the erector spinæ (*sacro-spinalis*) muscle, and its aponeurosis is the posterior layer of the lumbar fascia. Its fibers converge to the common tendon; the superior fibers pass horizontally lateralward over the inferior angle of the scapula, the middle ones, obliquely upward and lateralward, and the inferior ones, almost vertically upward. At the side of the chest they form a long, thick, fleshy mass, which sometimes receives an additional slip from the inferior angle of the scapula, and passes along the axillary border of that bone in contact with the teres major muscle, around which the latissimus dorsi turns. It is *inserted* into the base of the bicipital groove (*intertubercular sulcus*) between the insertions of the teres major and pectoralis major muscles by a flat tendon about seven centimeters (two and three-quarters inches) long. Near its insertion it twists upon itself so that the inferior fibers have the higher insertion, and the superior ones the lower insertion. The inferior margin of the tendon is united to that of the teres major muscle, from which it is usually separated by a bursa. Sometimes there is another bursa between this muscle and the inferior angle of the scapula. It turns spirally around the teres major and with it forms the posterior fold of the axilla.

The latissimus dorsi is subcutaneous throughout its entire extent, except at that portion of its origin where it is overlapped by the trapezius muscle. It lies, from below upward, upon: the vertebral aponeurosis which covers the erector spinæ (*sacro-spinalis*) muscle and its upward continuations, the serratus posterior inferior muscle, the lower ribs, the external intercostals, the serratus magnus (*serratus anterior*) muscle, the inferior angle of the scapula, the rhomboideus major, infraspinatus, and teres major muscles. Just above the crest of the ilium is the *triangle of Petit* (*lumbar triangle*), a triangular interval bounded inferiorly, by the crest of the ilium, posteriorly, by the anterior border of the latissimus dorsi muscle, and anteriorly, by the posterior border of the external oblique muscle. Its floor is formed by the internal oblique muscle. In very muscular subjects,

this triangle is obliterated because the posterior border of the external oblique is overlapped by the latissimus dorsi muscle. This triangle is occasionally the site of a low lumbar hernia, and a psoas abscess may point through it. With the arm abducted, a small triangular interval is seen between the superior border of the latissimus dorsi muscle, the vertebral border of the scapula, and the trapezius muscle. In the floor of this triangle are found the inferior part of the rhomboideus major muscle and the sixth intercostal space. With the exception of the median line of the sternum, this is the only part of the wall of the thorax not covered by muscle.

Blood Supply.—From the subscapular artery.

Nerve Supply.—From the long subscapular (*thoraco-dorsal*) nerve.

Action.—It is a medial rotator of the humerus and draws the arm downward (adduction) and backward (retraction). Acting from its insertion it elevates the lower ribs, as in forced inspiration, flexes the spinal column laterally, and draws the trunk and pelvis forward and upward; hence, it is much used in horizontal-bar exercises and in climbing. It is well developed in swimmers, as it draws the arm downward and at the same time rotates it medialward.

Dissection.—The trapezius muscles should now be cut through about three centimeters (one and a quarter inches) from its vertebral attachment and reflected lateralward, carrying with it the deep layer of the deep fascia which covers the under surface of the muscle. Dissection of the deep surface of the trapezius muscle exposes the spinal accessory (*accessory*) nerve, branches of the cervical plexus, and the terminal portion of the superficial cervical (*ascending branch of transverse cervical*) artery. The nerve filaments join to form the subtrapezial plexus, twigs from which supply the muscle. In close relation with the inferior portion of the spinal accessory nerve is the superficial cervical (*ascending branch of transverse cervical*) artery, which, if traced downward to the anterior border of the trapezius muscle, will be seen to arise from the transverse cervical artery.

Reflect the trapezius muscle and expose a group of three muscles attached to the posterior, or vertebral, border of the scapula: the levator anguli scapulæ (*levator scapulæ*), above the base of the spine; the rhomboideus minor, opposite the base of the spine; and the rhomboideus major, below the base of the spine; also the posterior (*inferior*) belly of the omo-hyoid muscle, which arises from the superior border of the scapula medial to the suprascapular (*small scapular*) notch.

The **levator anguli scapulæ** (**levator scapulæ**) **muscle** *arises* from the posterior tubercles of the transverse processes of the upper four cervical vertebræ by four tendinous slips, the superior two being the largest. These slips unite to form a prismatic, fleshy mass, which passes down the back of the side of the neck to be *inserted* into the vertebral border of the scapula, from the superior angle to the

root of the spine. Its superficial surface is in relation with the deep fascia of the neck, the scalenus medius, the trapezius, and the sterno-mastoid muscles, the internal jugular vein, the spinal accessory (*accessory*) nerve, and some of the descending branches of the cervical plexus. It rests upon the splenius colli (*splenius cervicis*), transversalis cervicis (*longissimus cervicis*), cervicalis ascendens (*ilio-costalis cervicis*), and serratus posterior superior muscles, and the posterior scapular (*descending branches of transverse cervical*) vessels.

Blood Supply.—From the vertebral, ascending cervical, superficial cervical (*ascending branch of transverse cervical*), and posterior scapular (*descending branch of transverse cervical*) arteries.

Nerve Supply.—From the posterior scapular (*dorsalis scapulæ*) branch of the fifth cervical nerve, and from additional filaments from the third and fourth cervical nerves.

Action.—It draws the upper angle of the scapula upward and forward, at the same time rotating that bone so as to depress the summit of the shoulder. Acting from its insertion, it inclines the neck to one side and extends it.

The **rhomboideus minor** is a narrow ribbon-like **muscle** *arising* from the inferior end of the ligamentum nuchæ, the seventh cervical and first thoracic spines, and the supraspinal ligament. It extends obliquely downward and lateralward, and is *inserted* into the vertebral border of the scapula opposite the base of the spine. It is covered by the trapezius muscle, and lies upon the serratus posterior superior and intercostal muscles, the posterior scapular (*descending branch of transverse cervical*) artery, and the ribs.

Blood Supply.—From the posterior scapular (*descending branch of transverse cervical*) artery.

Nerve Supply.—From the posterior scapular (*dorsalis scapulæ*) branch of the fifth cervical nerve which will be seen beneath the rhomboidei.

Action.—It draws the scapula upward and medialward toward the spinal column, antagonizing the action of the serratus magnus (*serratus anterior*).

The **rhomboideus major muscle** lies below the rhomboideus minor, and is about three times as broad. It *arises* from the upper four or five thoracic spines and their supraspinal ligaments, and is *inserted* by a tendinous cord into the vertebral border of the scapula opposite the infraspinous fossa.

Its relations are similar to those of the rhomboideus minor, except that it covers part of the splenius colli (*splenius cervicis*), the vertebral aponeurosis, and the erector spinæ (*sacro-spinalis*) muscle. The greater part of the muscle is covered by the trapezius, except near the inferior angle of the scapula where it lies subjacent to the deep fascia.

Blood Supply.—From the posterior scapular (*descending branch of transverse cervical*) artery.

Nerve Supply.—From the posterior scapular (*dorsalis scapulæ*) branch of the fifth cervical nerve.

Action.—It draws the scapula upward and medialward toward the spinal column, and rotates it so as to depress the summit of the shoulder.

Dissection.—Remove the fatty tissue covering the posterior belly of the omo-hyoid muscle and expose its orgin, partly from the superior border of the scapula just medial to the suprascapular (*small scapular*) notch, and partly from the ligament converting the notch into a foramen. The muscle passes forward and upward into the neck.

Divide the posterior belly of the omo-hyoid muscle a short distance above its origin and reflect it upward. This will expose the suprascapular (*transverse scapular*) artery and suprascapular nerve as they enter the suprascapular fossa.

Before dividing the levator anguli scapulæ (*levator scapulæ*) and rhomboidei muscles study the cap of the shoulder, which covers many important structures.

The **cap of the shoulder** is formed by the deltoid muscle which is covered by a part of the deep fascia, called the deltoid aponeurosis. This aponeurosis is thick and strong, and sends many septa between the bundles of fibers of the muscle. The fascia is continuous with that covering the pectoralis major muscle in front and the infraspinatus muscle behind, and is attached to the clavicle, the acromion, and the spine of the scapula.

The **deltoid muscle** resembles an inverted triangle with an indented base, or the Greek Δ inverted—hence its name. It is a coarsely fasciculated muscle whose origin is from the shoulder girdle opposite the insertion of the trapezius muscle, and so prominent that the clavicle, the acromion process, and the spine of the scapula seem like mere bony interruptions in one great trapezo-deltoid muscle which is inserted into the middle of the humerus. It *arises* from the lateral third of the anterior border of the clavicle, the lateral border and superior surface of the acromion process, and the entire inferior border of the spine of the scapula. From these points its fibers converge to form a thick, short tendon, which is *inserted* into the middle of the lateral side of the shaft of the humerus opposite the insertion of the coraco-brachialis muscle. Its fibers run an irregular course, twisting and coiling behind one another. There are several main fiber bundles. Many tendinous intermuscular septa, inward expansions of the deep fascia enveloping the lateral surface of the muscle, subdivide it, giving insertion to some of its fibers and origin to others, the largest bundle coming from the tip of the acromion. Superficially, this muscle is in relation with the platsyma, the deep fascia, and the supra-acromial (*posterior supraclavicular*) nerves. It almost completely envelopes the shoulder-joint, and is separated from the greater tuberosity of the humerus by the large, sacculated, subdeltoid bursa, which is often the seat of inflammation in the form of acute and chronic bursitis. In

some injuries of the shoulder, involvement of this bursa produces marked increase of the fluid contents of the sac. This traumatic bursitis causes much prominence of the shoulder cap, and the resulting increased pressure accounts for much of the pain produced by abduction of the arm. The deltoid covers the coracoid process of the scapula, the tendons of the pectorales major and minor, the coraco-brachialis, the subscapularis, the short and long heads of the biceps, the supra-spinatus, the infraspinatus, the teres minor, the long and the lateral heads of the triceps, the coraco-clavicular and coraco-acromial ligaments, the circumflex vessels and nerve (*axillary nerve*), and the proximal end of the humerus. Anteriorly, it adjoins the superolateral margin of the pectoralis major muscle, with which it forms the delto-pectoral sulcus in which is lodged the cephalic vein and the descending branch of the acromio-thoracic (*thoraco-acromial*) artery. Pyarthosis of the shoulder-joint, or abscess of the subdeltoid bursa, rarely burrows through the substance of this muscle but usually points at one of its borders.

Atrophy of the deltoid muscle causes the acromion process to appear more prominent, and produces a depression beneath it. This condition may be caused by disuse, as in ankylosis of the shoulder-joint; more frequently by disease of the spinal cord, such as acute anterior poliomyelitis; by ascending neuritis of the circumflex (*axillary*) nerve, usually due to disease of the shoulder-joint and causing paralysis of the muscles, or to injury of the circumflex (*axillary*) nerve. A careless observer may mistake a case of atrophy of the deltoid for dislocation of the head of the humerus.

Blood Supply.—From the acromio-thoracic (*thoraco-acromial*), the anterior and posterior circumflex arteries.

Nerve Supply.—From the terminal branches of the circumflex (*axillary*) nerve.

Action.—The whole muscle abducts the arm, raising it to a right angle with the body. The posterior fibers retroduct the arm and rotate it lateralward; the anterior fibers draw the arm forward and rotate it medialward. Thus, this muscle has the complex function of drawing the arm forward, backward, or lateralward, and rotating it medialward or lateralward.

Dissection.—Divide the deltoid muscle about two and a half centimeters (one inch) from its origin, and reflect it downward. This will expose the structures already enumerated as in relation with its under surface. When reflecting the muscle, the bursa separating the deltoid muscle from the acromion process and the greater tuberosity may have been opened; if it is still intact, it should be incised and its extent carefully noted by passing the finger into it.

Divide the latissimus dorsi muscle just above the level of the inferior angle of the scapula, and reflect the two portions; the inferior portion, however, should not be reflected beyond its aponeurosis.

Circumflex arteries and circumflex (axillary) nerve.—The anterior and posterior circumflex arteries and the circumflex (*axillary*) nerve (described with the dissection of the axilla), will be seen on the under surface of the reflected deltoid muscle.

The **teres major muscle** (Plate CLXXI) *arises* from the inferior third of the axillary border of the scapula, except for a small area at the inferior angle of the scapula, and from the fibrous septum between the teres major and the teres minor muscles. It passes upward and lateralward, and forms a short, flat tendon, which is inserted into the posterior bicipital ridge (*medial border of the sulcus intertubercularis*) of the humerus, behind the tendon of the latissimus dorsi muscle, from which it is separated by a bursa.

Blood Supply.—From the subscapular and posterior circumflex arteries.

Nerve Supply.—From the lower subscapular nerve.

Action.—It assists the latissimus dorsi muscle in adducting the arm and rotating it medialward; with the arm fixed upward and forward, it rotates the scapula by drawing the inferior angle forward; and with the scapula fixed, it assists the latissimus dorsi muscle in drawing the trunk upward and forward, as in climbing.

The **infraspinous fascia** is a dense membrane which covers the infraspinatus and teres minor muscles. It is attached to the circumference of the infraspinous fossa, and gives origin to some of the fibers of the muscles which it covers. At the lateral border of the deltoid it gives off a process which passes over that muscle. This fascia must be removed to expose the underlying muscles.

The **teres minor muscle** hugs the axillary border of the scapula, from the superior two-thirds of the dorsal surface of which it *arises*. There is an aponeurotic lamina between it and the teres major muscle, and a lamina between it and the infraspinatus muscle. It passes upward and lateralward, diverging slightly from the teres major muscle, and is *inserted* under cover of the deltoid, by a thick, flat tendon into the lowermost of the three facets upon the greater tuberosity of the humerus, the bone just below it, and the capsule of the shoulder joint. It is covered by the infraspinous fascia, the deltoid muscle, and the deep fascia, while beneath it are the scapula, the dorsalis scapulæ (*circumflex scapular*) artery, the long head of the triceps muscle, the teres major and subscapularis muscles, and the back of the shoulder-joint. Its superior border is in contact with the infraspinatus muscle, while its inferior border assists in forming the superior boundary of the subscapular triangle.

Blood Supply.—From the posterior circumflex and dorsalis scapulæ (*circumflex scapular*) arteries.

Nerve Supply.—From the circumflex (*axillary*) nerve.

Action.—It rotates the humerus laterally, adducts it, protects the back of the shoulder-joint, and aids in holding the head of the humerus in place.

The **long head of the triceps brachii muscle** is seen *arising* from the axillary border of the scapula just below the glenoid fossa. It passes distally toward the posterior surface of the arm, between the two teres muscles, and through the triangular space formed by their divergence (the teres minor being posterior and the teres major anterior), subdividing this interval into a medial triangular and a lateral quadrilateral space. (See Dissection of Axilla, at p. 59.) The former gives passage to the dorsalis scapulæ (*circumflex scapular*) vessels, and the latter to the posterior circumflex vessels and the circumflex (*axillary*) nerve.

The **scapula** has three fossæ, two dorsal ones, separated by the spine of the bone, and an anterior, or ventral, one, from each of which arises a muscle: the supraspinatus, the infraspinatus, and the subscapularis.

The **infraspinatus muscle,** thick and triangular, *arises* from the medial two-thirds of the infraspinous fossa, the under surface of the spine of the scapula, the infraspinous fascia, and the septum separating it from the teres major and teres minor muscles. Its fibers converge to a tendon which passes below the concave lateral border of the spine of the scapula, and crosses the shoulder-joint to be *inserted* into the middle facet upon the greater tuberosity of the humerus. A bursa, which sometimes communicates with the shoulder-joint, usually exists between the tendon and the neck of the scapula. This muscle is covered by the *infraspinous fascia,* which sends fibrous septa between it and the two teres muscles, and is continuous with the deep fascia of the arm. It is also covered by the deltoid, trapezius, and latissimus dorsi muscles. Beneath it lie the scapula, the suprascapular (*transverse scapular*) vessels, the suprascapular nerve, the dorsalis scapulæ (*circumflex scapular*) vessels, and the capsule of the shoulder-joint. Lateral to it are the teres major and teres minor muscles.

Blood Supply.—From the dorsalis scapulæ (*circumflex scapular*) and suprascapular (*transverse scapular*) arteries.

Nerve Supply.—From the suprascapular nerve.

Action.—It rotates the humerus lateralward, and with the arm in abduction retracts it, and aids in holding the head of the humerus in place.

Dissection.—The acromial end of the clavicle and the acromion process should be removed so as fully to expose the top of the shoulder-joint, and afford a clearer view of the muscles inserted into the greater tuberosity of the humerus.

The **supraspinous fascia** is a dense membrane covering the supraspinatus muscle, and giving origin to some of its fibers. It is very thick medially, but less so under the coraco-acromial ligament. It is attached to the margins of the supraspinous fossa, and must be removed to expose the supraspinatus muscle.

The **supraspinatus muscle** fills the supraspinous fossa, and *arises* from its medial two-thirds, the superior surface of the spine of the scapula, and the fascia covering the muscle. Its fibers converge into a short, stubby tendon which crosses the top of the shoulder-joint under the acromion process, to be attached to the uppermost of the three facets upon the greater tuberosity of the humerus and into the capsule of the shoulder-joint. Superficial to it are the thick and dense supraspinous aponeurosis, the trapezius muscle, the clavicle, the acromion, the coraco-acromial ligament, and the deltoid muscle; under it are the capsule of the shoulder-joint, the suprascapular (*transverse scapular*) vessels, the suprascapular nerve, the omo-hyoid muscle, and the scapula.

Blood Supply.—From the suprascapular (*transverse scapular*) artery.

Nerve Supply.—From the suprascapular nerve.

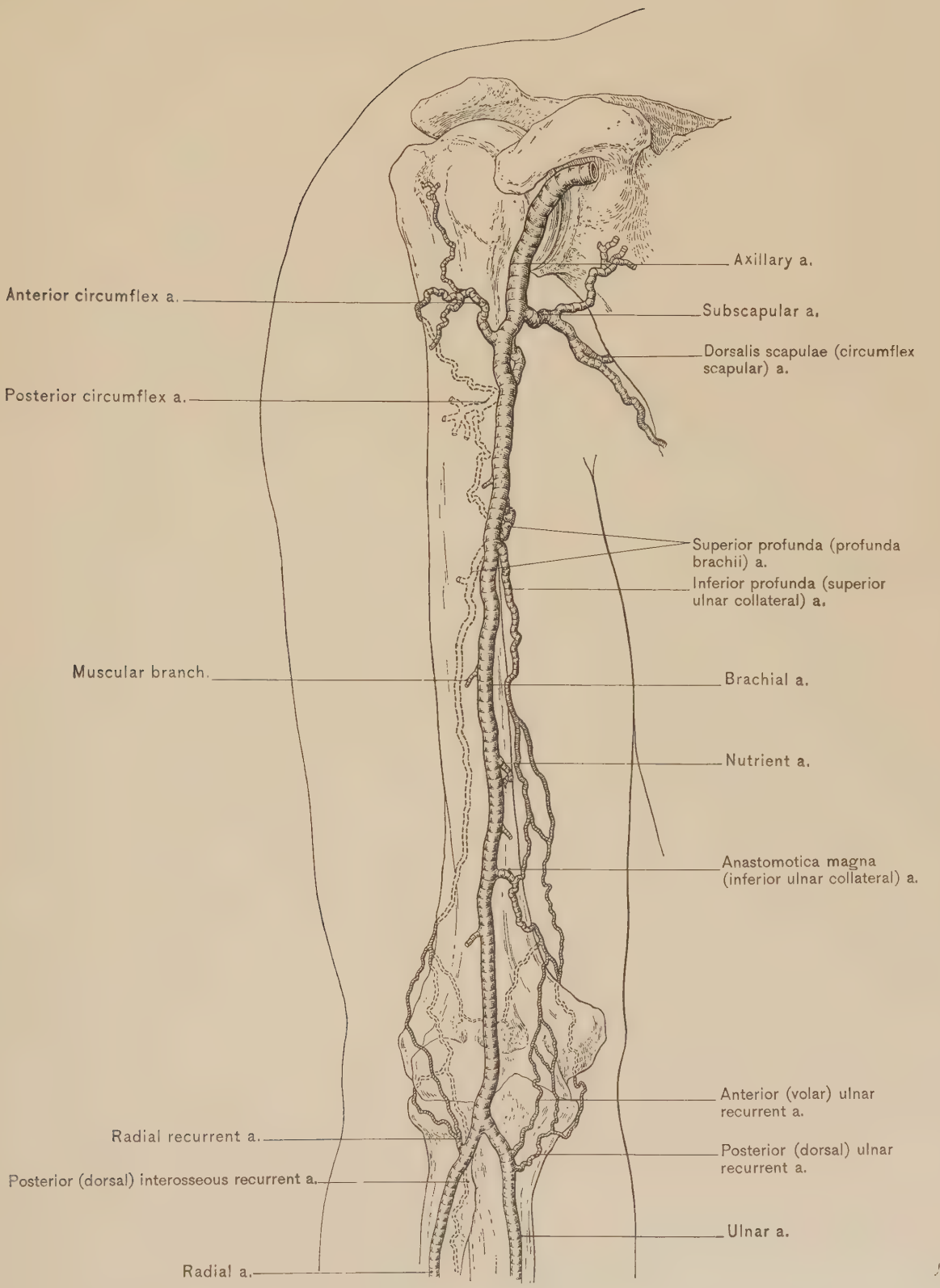
Action.—It assists the deltoid muscle in abducting the arm, and holds the head of the humerus in contact with the glenoid fossa.

Dissection.—In order to obtain a better view of the vessels and nerve which pass beneath the muscles just described, divide the levator anguli scapulæ (*levator scapulæ*) muscle near its attachment to the base of the scapula and reflect it upward; divide the infraspinatus and supraspinatus muscles near their insertions and reflect them medialward; divide the rhomboidei muscles near their insertion and reflect them lateralward, and the teres minor muscle near its insertion and reflect it downward.

The **posterior scapular** (**descending branch of transverse cervical**) **artery,** one of the branches of the transversalis cervicis (*transverse cervical*) runs beneath the vertebral border of the scapula, between the levator anguli scapulæ (*levator scapulæ*) and the rhomboidei muscles behind, and the serratus magnus (*serratus anterior*) muscle in front, to the inferior angle of the scapula, where it anastomoses with the terminal portion of the subscapular artery. In its course it gives off numerous branches, which ramify on the dorsal and ventral aspects of the scapula. These branches supply the rhomboidei, supraspinatus, infraspinatus, trapezius, and latissimus dorsi muscles. They anastomose with the suprascapular (*transverse scapular*), dorsalis scapulæ (*circumflex scapular*), subscapular, and branches of the intercostal arteries. The posterior scapular often arises from the third portion of the subclavian artery. The nerve to the rhomboidei muscles accompanies this artery.

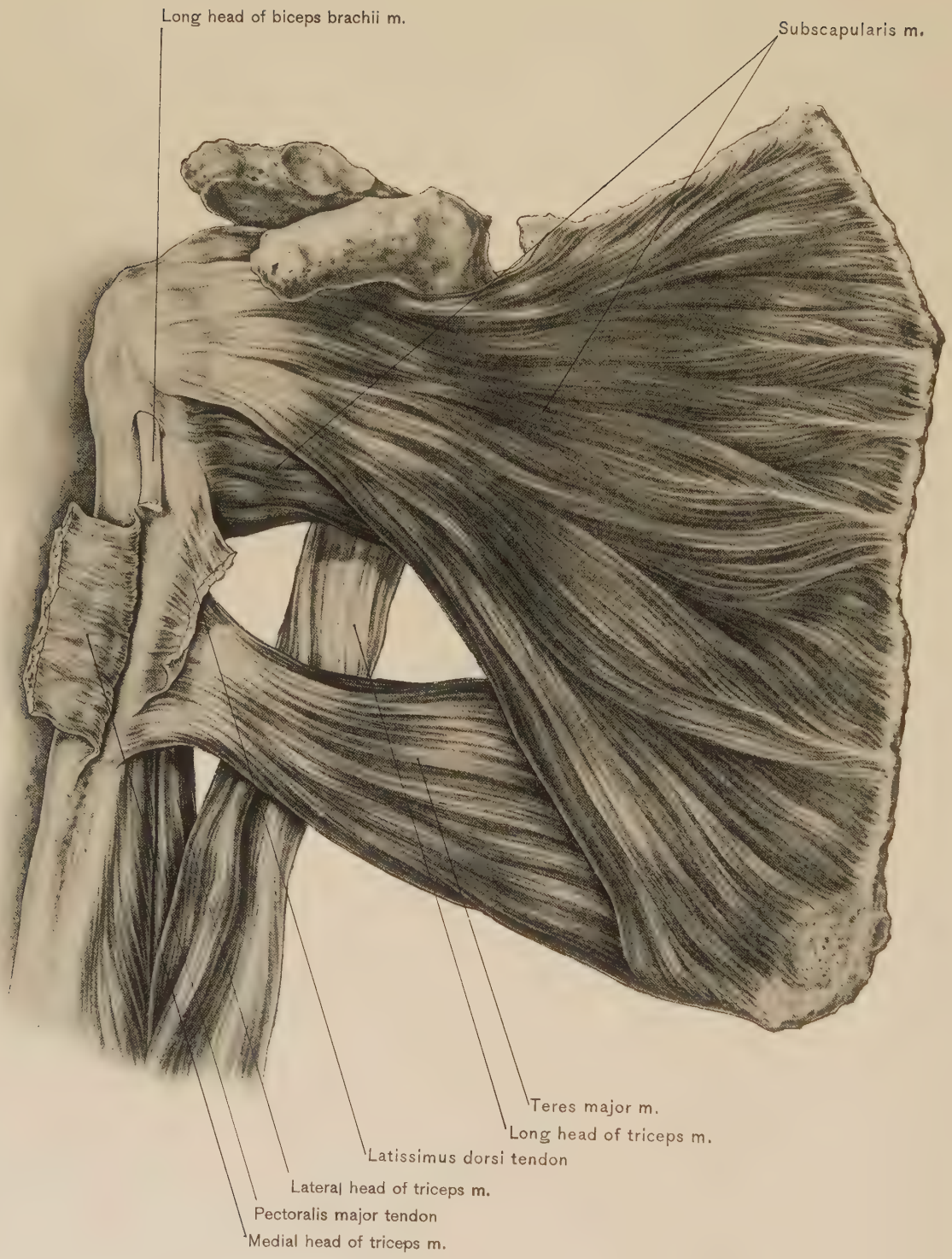
The **suprascapular** (**transverse scapular**) **artery** (Plate CCXVII), a branch of the thyroid axis (*thyro-cervical trunk*), after passing along the under surface of the posterior belly of the omo-hyoid muscle, enters the supraspinous fossa by passing over the transverse ligament. Traversing the supraspinous fossa beneath the supraspinatus muscle, it passes around the lateral border of the spine of the

PLATE CCXVII.



AXILLARY AND BRACHIAL ARTERIES AND THEIR BRANCHES.

PLATE CCXVIII.


Long head of biceps brachii m.
Subscapularis m.
Teres major m.
Long head of triceps m.
Latissimus dorsi tendon
Lateral head of triceps m.
Pectoralis major tendon
Medial head of triceps m.

SUBSCAPULARIS MUSCLE, SUBSCAPULAR TRIANGLE, AND TERES MAJOR MUSCLE.

scapula and enters the infraspinous fossa. Within these two fossæ it supplies the supraspinatus and infraspinatus muscles, and anastomoses with the posterior scapular (*descending ramus of the transverse cervical*) and dorsalis scapulæ (*circumflex scapular*) arteries.

The **suprascapular nerve** accompanies the suprascapular (*transverse cervical*) artery, but passes through the suprascapular notch beneath, instead of over, the superior transverse ligament. It supplies twigs to the supraspinatus muscle and the shoulder-joint, and together with the suprascapular (*transverse cervical*) artery passes into the infraspinous fossa, terminating in the infraspinatus muscle.

The **dorsalis scapulæ** (**circumflex scapular**) **artery,** a branch of the subscapular, enters the infraspinous fossa by passing through the triangular space and winding around the axillary border of the scapula under the teres minor muscle. It supplies the infraspinatus muscle, and anastomoses with the suprascapular (*transverse cervical*) and posterior scapular (*descending branch of the transverse cervical*) arteries. It sends a branch along the axillary border of the scapula, between the teres major and minor muscles, to the posterior surface of the inferior angle of that bone, where it again anastomoses with the posterior scapular (*descending branch of the transverse cervical*) artery.

The **subscapularis** (Plate CCXVIII), a large triangular **muscle,** fills the subscapular fossa. It *arises* from the whole of that fossa, and the groove along the axillary margin, excepting the surfaces at the angles of the bone. Its scapular origin is fleshy, except at the ridges on the bone, where it is tendinous. Its fibers converge to a strong tendon which lies below the base of the coracoid process, and is *inserted* into the lesser tuberosity of the humerus; the fibers arising from the axillary border are inserted by fleshy fibers into the surgical neck of the humerus for two and a half centimeters (one inch) below the lesser tuberosity under cover of the coraco-brachialis, and the short head of the biceps. A large bursa between its tendon and the coracoid process communicates with the shoulder-joint. The muscle is covered by a thin, *subscapular aponeurosis* attached to the entire circumference of the fossa, which gives origin to some of its fibers. In addition to this covering it lies behind the serratus magnus (*serratus anterior*), the coraco-brachialis, and the short head of the biceps muscles, the axillary vessels, and the brachial plexus and some of their branches. Posteriorly, it rests upon the scapula, the teres minor muscle, the long head of the triceps, the capsule of the shoulder-joint, and the intervening bursa. To its lateral side are the teres major and the latissimus dorsi muscles, the posterior circumflex and dorsalis scapulæ (*circumflex scapular*) vessels, and the circumflex (*axillary*) nerve.

Blood Supply.—From the axillary and subscapular arteries.

Nerve Supply.—From the short (*upper*) subscapular, which often is double, and the middle (*lower*) subscapular nerves.

Action.—It rotates the humerus medially, draws the arm forward, and holds the head of the humerus in place.

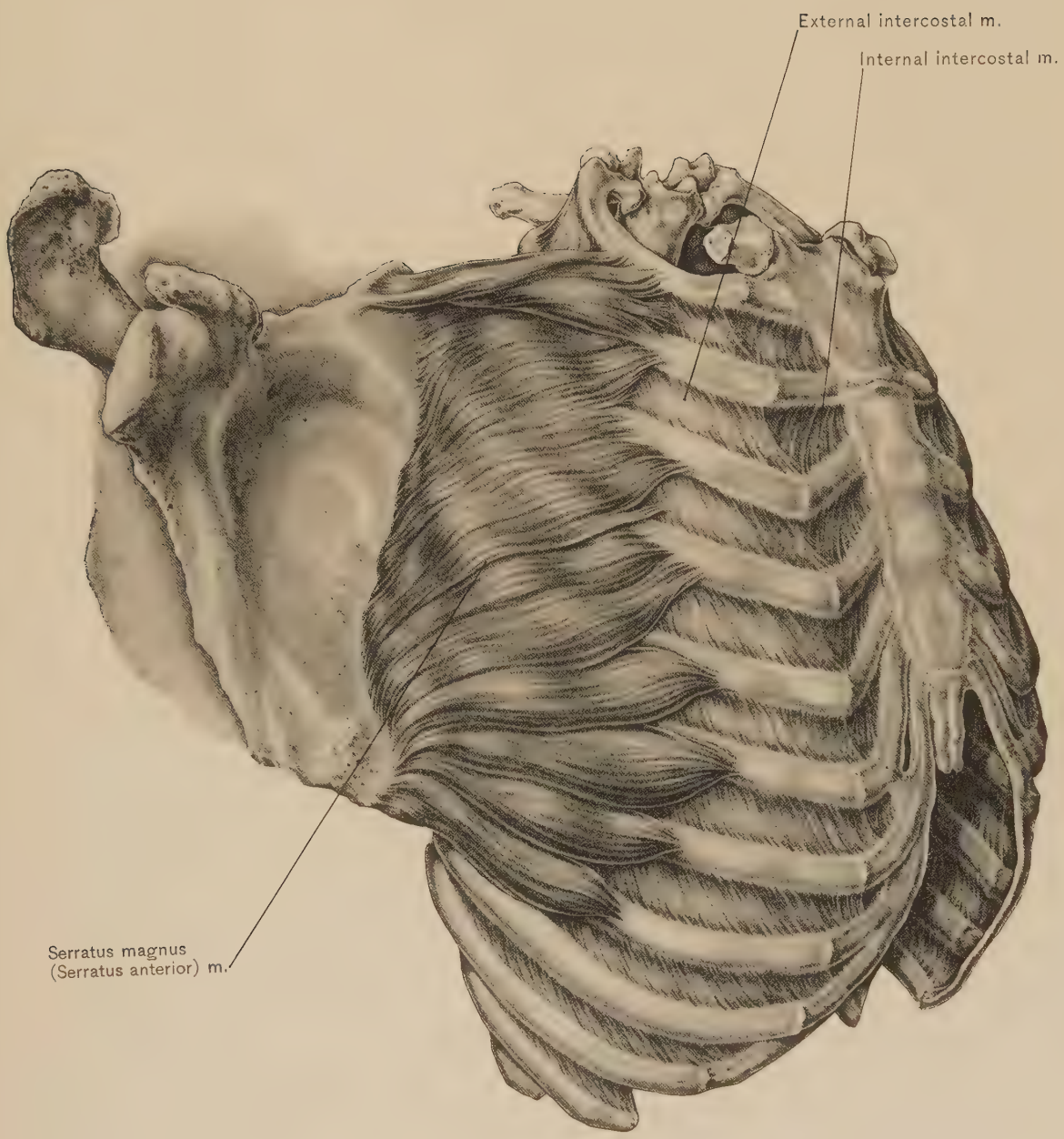
Dissection.—The anterior dissection of the chest having been made, the clavicle should be severed; the serratus magnus (*serratus anterior*) muscle will now be the only remaining connection between the trunk and the upper extremity.

The **serratus magnus** (**serratus anterior**) **muscle** (Plate CCXIX) is closely attached to the superolateral, anterior part of the thorax. It *arises* by nine or ten fleshy digitations, or slips, from the upper eight ribs and the corresponding interspaces, two of the digitations arising from the second rib. From this broad origin its fibers converge backward around the chest for *insertion* into the entire length of the anterior surface of the vertebral border, and the superior (*medial*) and inferior angles of the scapula. It is thus irregularly quadrilateral in form. It is conveniently divided for examination into a superior, middle, and inferior part. The *superior portion*, the narrowest, thickest, and shortest portion, consists of the first two digitations arising from the first and second ribs and the intervening intercostal space, whence it passes upward, lateralward, and backward to the anterior surface of the superior (*medial*) angle of the scapula. The *middle portion* consists of the third, fourth, and fifth digitations, arising from the second, third, and fourth ribs and the intervening intercostal spaces. This is a thinner and wider layer than the preceding portion, and passes horizontally backward to be *inserted* into the anterior surface of the vertebral border of the scapula between its superior (*medial*) and inferior angles. The *inferior portion* consists of the remaining four digitations arising from the fifth, sixth, seventh, and eighth ribs and the corresponding intervals, which interdigitate with the superior serrations of the external oblique muscle. Its fibers pass upward, lateralward, and backward, to be inserted into the oval space on the anterior surface of the inferior angle of the scapula. The serratus magnus (*serratus anterior*) muscle is in relation, superficially, with the pectorales major and minor, the subscapularis and the latissimus dorsi muscles, the subclavian and axillary vessels, the brachial plexus of nerves, and the posterior, or long, thoracic nerve. It covers the ribs, the intercostal muscles, and the serratus posterior superior muscle.

Blood Supply.—From the axillary and intercostal arteries.

Nerve Supply.—From the posterior, or long, thoracic nerve (external respiratory nerve of Bell). This nerve is seen running over the muscle at the side of the chest. After piercing the scalenus medius, the nerve enters the axilla and supplies branches to the superficial surface of the several digitations of the muscle.

PLATE CCXIX.



SERRATUS MAGNUS (SERRATUS ANTERIOR) MUSCLE.

ACTION.—It draws the scapula and the entire shoulder forward, thus increasing the forward reach of the arm and antagonizing the rhomboidei muscles and the central fibers of the trapezius muscle. If the scapulæ are fixed close to the spinal column, the inferior fibers of the two serratus magnus (*serratus anterior*) muscles will evert and draw the ribs upward, thus pushing the sternum outward and increasing the anteroposterior and lateral diameters of the chest. It helps sustain weight upon the shoulder by holding the inferior angle of the scapula forward, thus aiding the trapezius in drawing the summit of the shoulder upward. It holds the scapulæ firmly against the chest wall, and its inferior portion, which is by far the strongest, pulls the inferior angle of the scapula forward. It supports the scapula, while the deltoid muscle abducts the arm to a right angle; then, by rotating the inferior angle forward, it helps to raise the arm to the vertical position. Paralysis of the serratus magnus (*serratus anterior*) muscle prevents the deltoid from raising the arm, and allows the inferior angle and vertebral border of the scapula to project from the chest, producing the "winged scapula."

Before leaving the shoulder the student should carefully note the actions and relations of the magnificent tripartite muscle composed of the trapezius, deltoid, and pectoralis major muscles. The trapezius and deltoid may be considered a single muscle; the pectoralis major and deltoid muscles also may be regarded as one muscular mass, arising from an extensive origin, beginning at the costochondral margin and extending up the side of the sternum and along the entire length of the shoulder girdle, the clavicle, the acromion, and the spine of the scapula. It is inserted into the anterior bicipital ridge (*lateral border of the sulcus intertubercularis*) and the middle of the lateral side of the shaft of the humerus.

The following grouping of the seventeen muscles attached to the scapula will aid the student in remembering them:

Three to the vertebral border	Serratus magnus (*serratus anterior*) muscle. Rhomboideus minor muscle. Rhomboideus major muscle.
Three to the axillary border	Long head of triceps brachii muscle. Teres minor muscle. Teres major muscle.
Three to the three fossæ	Supraspinatus muscle. Infraspinatus muscle. Subscapularis muscle.
Three to the coracoid process	Short head of biceps brachii muscle. Coraco-brachialis muscle. Pectoralis minor muscle.

Three irregularly attached	Omo-hyoid muscle. Long head of biceps brachii muscle. Levator anguli scapulæ (*levator scapulæ*) muscle.
Two to the spine of the scapula	Trapezius muscle. Deltoid muscle.

Dissection.—Remove the arm and the scapula by dividing the coraco-clavicular ligament, the serratus magnus (*serratus anterior*) muscle at its origin, and the axillary vessels and brachial plexus of nerves. This exposes the two serratus muscles, the superior one lying under the three muscles attached to the vertebral border of the scapula, and the inferior under the latissimus dorsi muscle.

The **serratus posterior superior** (Plate CCXX) is a thin, flat **muscle** *arising* by a thin aponeurosis from the lower end of the ligamentum nuchæ and the last cervical and the upper two or three thoracic spines. Its fibers are directed downward and lateralward, and are *inserted* by four fleshy slips into the superior borders of the second, third, fourth, and fifth ribs beyond their angles. It is covered by the trapezius and the levator anguli scapulæ (*levator scapulæ*) and the rhomboidei muscles, and crosses over the splenius, the erector spinæ (*sacro-spinalis*), and complexus (*semispinalis capitis*) muscles. It lies upon the vertebral aponeurosis covering the upper continuations of the erector spinæ (*sacro-spinalis*), upon the intercostal muscles, and the ribs.

Blood Supply.—Branches of the intercostal, and the deep cervical arteries.

Nerve Supply.—From the branches of the second and third intercostal nerves.

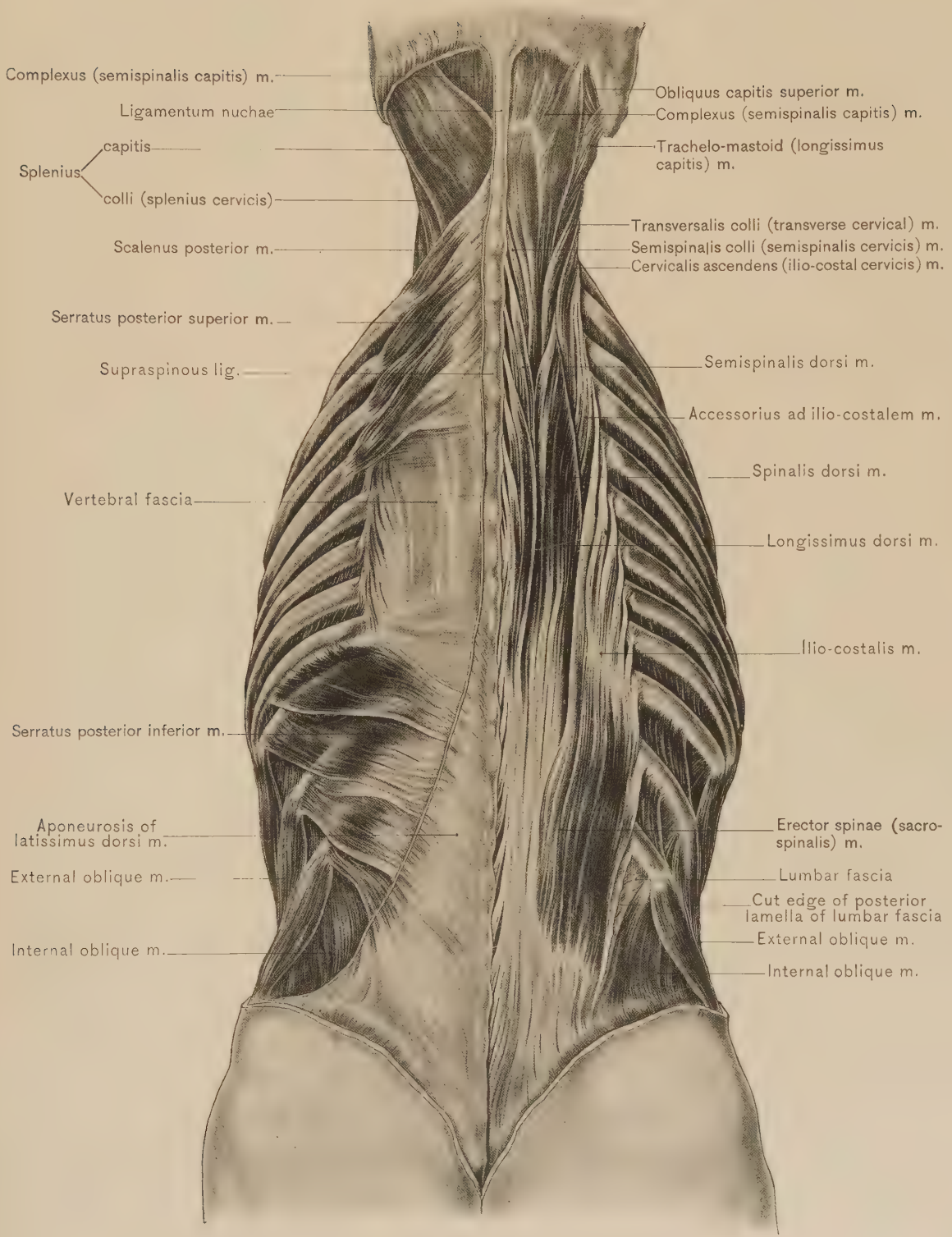
Action.—It raises the ribs to which it is attached, and is an accessory muscle of inspiration. It also assists in lateral movement of the vertebral column when the ribs are fixed.

The **serratus posterior inferior** is also a thin, flat **muscle.** It *arises* by an aponeurosis from the last two dorsal and the upper two or three lumbar spines and from the supraspinal ligaments between them. This is obtained through the medium of the lumbo-dorsal fascia, with which the aponeurotic tendon of the muscle blends. It passes upward and lateralward, and is *inserted* by four fleshy digitations into the inferior borders of the lower four ribs beyond their angles. It is covered by the latissimus dorsi muscle and rests upon the erector spinæ (*sacro-spinalis*) and its continuations, upon the levatores costarum and the intercostal muscles and ribs. Its superior margin blends with the vertebral aponeurosis.

Blood Supply.—Branches of the intercostal arteries.

Nerve Supply.—From the branches of the tenth and eleventh intercostal nerves.

PLATE CCXX.



MUSCLES OF BACK.

Action.—It depresses and fixes the lower four ribs, resisting the action of the diaphragm, which tends to elevate and draw these ribs forward; it is an accessory muscle of inspiration.

The **splenius muscle,** comprising the **splenius capitis and cervicis,** *arises* from the lower two-thirds of the ligamentum nuchæ and, by tendinous slips, from the spines of the last cervical and the upper six thoracic vertebræ and the intervening supraspinal ligaments. It passes upward and lateralward, expanding into a broad, flat muscle which divides into two portions, one going to the head and the other to the neck. The head, or median, segment, *splenius capitis,* is *inserted* into the mastoid process of the temporal bone and the lateral part of the superior curved (*superior nuchal*) line under the sterno-mastoid muscle. The neck segment, the *splenius cervicis,* turns anteriorly and is *inserted* into the posterior tubercles of the transverse processes of the upper three cervical vertebræ, medial to the origin of the levator anguli scapulæ (*levator scapulæ*). The muscle is covered by the posterior process of the deep cervical fascia and by the following muscles: trapezius, serratus posterior superior, rhomboidei, levator anguli scapulæ (*levator scapulæ*), sterno-mastoid. It lies upon the spinalis dorsi, semispinalis colli (*semispinalis cervicis*), longissimus dorsi, cervicalis ascendens (*ilio-costalis cervicis*), transversalis cervicis (*longissimus cervicis*), complexus (*semispinalis capitis*), and trachelo-mastoid (*longissimus capitis*) muscles.

Blood Supply.—From the occipital artery and descending branches, the superficial cervical (*ascending branch of transverse cervical*) and ascending branches, and branches of the vertebral and the deep cervical arteries.

Nerve Supply.—From the lateral branches of the posterior divisions of the lower cervical and upper thoracic nerves.

Action.—The *splenius capitis* inclines the head and neck, rotates them to the same side and flexes them laterally. The *splenius cervicis* extends the spine and aids in lateral and rotatory movements. When both muscles act the head and neck are extended.

The **vertebral fascia, or vertebral aponeurosis,** is a thin, fibrous membrane, which extends from the spines of the vertebræ to the angles of the ribs, and binds down the muscles occupying the vertebral groove. It is continuous inferiorly, with the superior margin of the serratus posterior inferior muscle and the aponeurosis of the latissimus dorsi muscle; superiorly, it passes under the serratus posterior superior, and is continuous with the deep fascia over the splenius muscle. This aponeurosis separates the deeper muscles of the back from the posterior axo-appendicular muscles—those muscles of the back which unite the trunk with the upper limb.

Dissection.—Beginning from below, remove the aponeurosis of the latissimus dorsi muscle, the serratus posterior inferior, and the vertebral fascia. Divide the serratus posterior superior and the splenius muscles at their middle, and reflect the two halves. This exposes the erector spinæ (*sacro-spinalis*) muscle and its upward continuations and the greater part of the complexus (*semi-spinalis capilis*) muscle.

The **erector spinæ** (**sacro-spinalis**) **muscle** (Plate CCXXI) is an extensive, sectional fibro-muscular mass with numerous costo-vertebral attachments extending the entire length of the spine. Densely fibrous and pointed in the sacral region, it becomes very muscular in the lumbar region, and in the lower dorsal region divides into three main columns: a lateral, sacro-lumbalis (*ilio-costalis lumborum*), a medial, spinalis dorsi, and an intermediate, longissimus dorsi. It *arises* by a thick aponeurosis from the spines of the lower two thoracic, the lumbar, and the upper four sacral vertebræ, and the supraspinal ligaments; from the back of the sacrum and the posterior sacro-iliac ligaments; by muscular fibers, from the posterior fifth of the crest of the ilium, and from the deep surface of the posterior layer of the lumbo-dorsal fascia. The whole mass ascends, and divides below the last rib into the three above-named columns.

The **lateral column** is subdivided into the sacro-lumbalis (*ilio-costalis lumborum*) and its continuations—the accessorius ad ilio-costalem (*ilio-costalis dorsi*) and the cervicalis ascendens (*ilio-costalis cervicis*) muscles.

Blood Supply.—From the posterior scapular (*descending branch of transverse cervical*), intercostal, and lumbar arteries.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the lumbar, thoracic, and cervical regions.

The **sacro-lumbalis** (**ilio-costalis lumborum**) is the lateral, fleshy part of the erector spinæ (*sacro-spinalis*) muscle, and is *inserted* into the angles of the ribs from the sixth to the eleventh, and into the inferior border of the twelfth, the transverse processes of the lumbar vertebræ, and into the middle layer of the lumbo-dorsal fascia. Sometimes this muscle is inserted as high as the fourth rib.

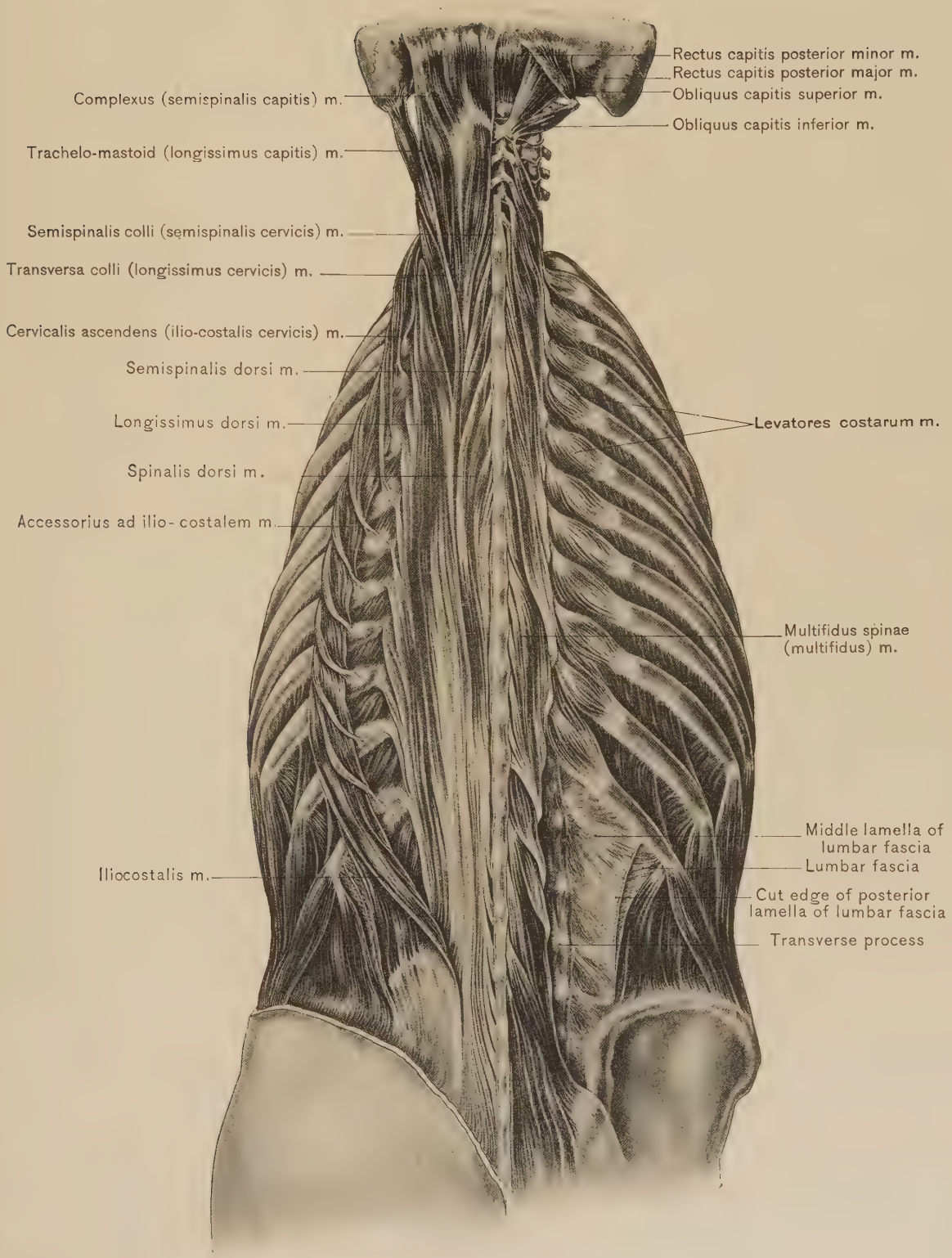
Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the lumbar and thoracic regions.

Action.—It depresses the ribs, and, therefore, is a muscle of expiration. It keeps the body erect by extending the spinal column, which it also flexes laterally.

Dissection.—Turn the sacro-lumbalis (*ilio-costalis lumborum*) muscle lateralward to expose the origins of the accessorius muscle.

The **accessorius** (**ilio-costalis dorsi**) **muscle,** or accessorius ad ilio-costalem, is the upward continuation of the sacro-lumbalis (*ilio-costalis lumborum*) muscle and *arises*, by tendinous slips, from the angles of the lower six ribs, medial to the

PLATE CCXXI.


Rectus capitis posterior minor m.
Rectus capitis posterior major m.
Obliquus capitis superior m.
Obliquus capitis inferior m.
Complexus (semispinalis capitis) m.
Trachelo-mastoid (longissimus capitis) m.
Semispinalis colli (semispinalis cervicis) m.
Transversa colli (longissimus cervicis) m.
Cervicalis ascendens (ilio-costalis cervicis) m.
Semispinalis dorsi m.
Longissimus dorsi m.
Spinalis dorsi m.
Accessorius ad ilio-costalem m.
Levatores costarum m.
Multifidus spinae (multifidus) m.
Middle lamella of lumbar fascia
Lumbar fascia
Cut edge of posterior lamella of lumbar fascia
Transverse process
Iliocostalis m.

DEEP MUSCLES OF BACK.

costal insertions of the sacro-lumbalis (*ilio-costalis lumborum*) muscle, and is *inserted* into the angles of the upper six ribs and the transverse process of the seventh cervical vertebra.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the thoracic region.

Action.—With fixation of the lower six ribs by the sacro-lumbalis (*ilio-costalis lumborum*), this muscle depresses the upper six ribs, as in expiration. It also aids in extension and lateral flexion of the spinal column; acting from its insertion, it elevates the lower six ribs and is an accessory muscle of inspiration.

The **cervicalis ascendens** (**ilio-costalis cervicis**) is the continuation of the accessorius (*ilio-costalis dorsi*) muscle and is the highest segment of the ilio-costalis. It *arises* from the upper four or five ribs medial to the costal insertions of the accessorius (*ilio-costalis dorsi*) muscle. It passes upward over the first rib and the transversalis cervicis (*longissimus cervicis*) muscle, and is *inserted* into the posterior tubercles of the transverse processes of the fourth, fifth, and sixth cervical vertebræ.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the thoracic and cervical regions.

Action.—It extends the neck and flexes it laterally. From its insertion, it elevates the ribs to which it is attached, and is an accessory muscle of inspiration.

In order properly to display the ilio-costal group the lowest segment should be everted first by the dissector and then the middle and the upper segments.

The **intermediate column**, which is the largest of the three muscle columns, consists of the longissimus dorsi, transversalis cervicis (*longissimus cervicis*), and trachelo-mastoid (*longissimus capitis*) muscles, and receives its blood supply from the princeps cervicis (*descending branch of occipital*), deep cervical, intercostal, and lumbar arteries.

The **longissimus dorsi muscle** is the largest of the erector spinæ (*sacro-spinalis*) group. In the lumbar region, its medial side lies in close contact with the spinalis dorsi muscle, from which it often receives a slip. It has two series of *insertions:* a medial, or vertebral series, attached by rounded tendons to the tips of the transverse processes of all of the thoracic and the accessory processes of the lumbar vertebræ; and a lateral series inserted by fleshy and tendinous slips into all of the ribs lateral to the tubercles, the transverse processes of the lumbar vertebræ, and the posterior surface of the middle lamella of the lumbo-dorsal fascia.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the lumbar and thoracic regions.

Action.—It extends the spinal column, flexes it laterally, and depresses the ribs, as in expiration.

The **transversalis cervicis** (**longissimus cervicis**) **muscle,** the upward continuation of the longissimus dorsi, is situated upon the medial side of that muscle. It *arises* from the transverse processes of the upper five or six thoracic vertebræ, and is *inserted* into the posterior tubercles of the transverse processes of the cervical vertebræ from the second to the sixth, inclusive.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the thoracic and cervical regions.

Action.—It extends the neck, flexes it laterally, and rotates it to the same side.

The **trachelo-mastoid** (**longissimus capitis**) **muscle** is situated upon the medial side of the transversalis cervicis (*longissimus cervicis*), and forms the continuation of that muscle toward the head. It is covered by the splenius. It *arises* from the transverse processes of the third, fourth, fifth, and sixth thoracic vertebræ and by additional tendons from the back of the articular processes of the lower three or four cervical vertebræ. It proceeds upward as a small muscle which is *inserted* into the posterior border of the mastoid process under the splenius capitis and sterno-mastoid muscles. It frequently has a tendinous intersection near its insertion.

Nerve Supply.—From the lateral branches of the posterior divisions of the spinal nerves in the thoracic and cervical regions.

Action.—It flexes the head laterally, rotates it to the same side, and, with the aid of its fellow, extends the head.

The **medial column** of the erector spinæ (*sacro-spinalis*) muscle consists of the **spinalis dorsi muscle,** and sometimes the **spinalis cervicis.** It is the most medial, the shortest, and weakest of the three columns which make up the erector spinæ group. It receives its blood supply from the intercostal and lumbar arteries.

The **spinalis dorsi muscle** is the continuation of the erector spinæ (*sacro-spinalis*) which *arises* from the upper two lumbar and the lower two thoracic spines. It is *inserted* into the spines of the second to the eighth or ninth thoracic vertebræ. Its latero-inferior side is closely connected with the longissimus dorsi muscle, and at its insertion, with the semispinalis dorsi muscle.

Nerve Supply.—From the posterior branches of the spinal nerves of the thoracic region.

Action.—It extends the spinal column and flexes it laterally.

The **spinalis cervicis muscle,** analogous to the spinalis dorsi, but not present in all subjects, generally extends from the fifth and sixth cervical spines to the spine of the axis (*epistropheus*). It varies considerably, and may be attached to two additional spines below the origin and insertion here given.

NERVE SUPPLY.—From the posterior branches of the cervical nerves.

ACTION.—It extends the neck and inclines it laterally.

The **complexus** (**semispinalis capitis**) is a broad, bulky **muscle** occupying the cervical and the upper thoracic regions, and passing upward and medialward to the occipital bone. It *arises* from the posterior surface of the transverse processes of the upper six thoracic and the last cervical vertebræ, the posterior surface of the articular processes of the lower three or four cervical vertebræ and the spine of the seventh cervical vertebra. It is *inserted* into the occipital bone between the superior and inferior curved (*inferior nuchal*) lines. A transverse tendinous intersection divides it into a superior and an inferior portion. It lies beneath the trapezius and the splenius muscles, lateral to the ligamentum nuchæ, which separates it from its fellow of the opposite side, and medial to the trachelo-mastoid (*longissimus capitis*) and transversalis cervicis (*longissimus cervicis*) muscles. It lies upon the obliquus capitis superior and inferior muscles, the rectus capitis posterior major and minor muscles, the semispinalis cervicis muscle, the deep cervical and princeps cervicis (*descending branch of occipital*) arteries, and the posterior division of the spinal nerves, including the greater occipital nerve which pierces it.

BLOOD SUPPLY.—From the deep cervical, princeps cervicis (*descending branch of occipital*), and superficial cervical arteries.

NERVE SUPPLY.—From the suboccipital, greater occipital, and medial branches of the posterior divisions of the third, fourth, and fifth cervical nerves.

ACTION.—It is a powerful extensor of the head and neck, flexes the head laterally, and turns the face slightly to the opposite side.

The more medial portion of the complexus (*semispinalis capitis*) is separated from the lateral parts and forms the **biventer cervicis,** a small, delicate, double-bellied muscle, with an intervening tendon, placed vertically in contact with the ligamentum nuchæ.

DISSECTION.—Sever the attachments of the erector spinæ (*sacro-spinalis*) and the spinalis dorsi muscles to the spines of the vertebræ and the insertions of the longissimus dorsi and the sacro-lumbalis (*ilio-costalis lumborum*) muscles, and reflect the muscles downward. Next detach the accessorius (*ilio-costalis dorsi*), the cervicalis ascendens (*ilio-costalis cervicis*), the transversalis cervicis (*longissimus cervicis*) and the trachelo-mastoid (*longissimus capitis*) muscles. Sever the complexus (*semispinalis capitis*) muscle where the greater occipital nerve pierces it, preserving the nerve intact; reflect the two portions, and expose the suboccipital and the other nerves which enter its deep surface.

In reflecting the trachelo-mastoid (*longissimus capitis*) and the complexus (*semispinalis capitis*) muscles avoid injuring the occipital, the princeps cervicis

(*descending branch of occipital*) and the deep cervical arteries and the deep cervical vein.

The **occipital artery** in the deepest part of its course will be found beneath the mastoid process of the temporal bone. At this point it is covered by the origin of the posterior belly of the digastric muscle, the mastoid process, the trachelo-mastoid (*longissimus capitis*), the splenius capitis, and sterno-mastoid muscles. Occasionally, in this part of its course, the artery is found between the splenius and the trachelo-mastoid (*longissimus capitis*). It winds through the interval between the mastoid process of the temporal bone and the transverse process of the atlas, being separated from the vertebral artery by the rectus capitis lateralis muscle, and then traverses the occipital groove upon the mastoid portion of the temporal bone. It crosses the superior oblique and a portion of the complexus (*semispinalis capitis*), and at the posterior border of the splenius pierces the trapezius muscle together with the greater occipital nerve. The artery reaches the scalp about mid-way between the external occipital protuberance and the mastoid process. The vessels arising from this portion of the artery are the princeps cervicis (*descending branch of occipital*), the mastoid, and muscular branches.

The **princeps cervicis** (**descending branch of occipital**) **artery** is given off near the posterior border of the splenius muscle, and passes to the lateral border of the complexus (*semispinalis capitis*), where it divides into a superficial and a deep branch. The *superficial branch* pierces the splenius, and, passing downward between that muscle and the trapezius, anastomoses with the superficial cervical (*ascending branch of transverse cervical*) artery. The *deep branch* passes downward between the complexus (*semispinalis capitis*) and semispinalis cervicis muscles and anastomoses with the deep cervical artery from the superior intercostal, and some small branches of the vertebral artery. By means of this anastomosis a collateral circulation is established after ligation of the carotid or subclavian artery.

The **mastoid, or meningeal, branch** passes through the mastoid foramen to supply the mastoid cells, the diploë, the walls of the lateral sinus, and the dura mater.

The **muscular branches** supply adjacent muscles.

The **deep cervical artery,** a branch of the superior intercostal (*costo-cervical trunk*), emerges from between the transverse process of the last cervical vertebra and the neck of the first rib, and, passing upward between the complexus (*semispinalis capitis*) and the semispinalis cervicis muscle, anastomoses with the princeps cervicis (*descending branch of the occipital*) artery and branches of the ascending cervical and vertebral arteries; it supplies adjacent muscles, and sends a spinal branch into the vertebral canal.

The **deep cervical vein,** formed by small veins in the suboccipital triangle, usually receives the occipital vein, and accompanying the princeps cervicis (*descending branch of occipital*) and the deep cervical arteries, empties into the vertebral or innominate vein.

The previous **dissection** exposed the deepest muscles of the back (Plate CCXXI), which, from below upward, are the following: the multifidus, the levatores costarum, the semispinalis, divided into semispinalis dorsi and cervicis; the posterior cranio-vertebral muscles, composed of the obliquus capitis superior and inferior, the rectus capitis posterior major and minor which together form the suboccipital triangle; also the middle layer of the lumbar (*lumbo-dorsal*) fascia, the occipital, the deep cervical arteries, and the greater occipital and suboccipital nerves.

Blood Supply.—These deep muscles are nourished by the vertebral, princeps cervicis (*descending branch of occipital*), deep cervical, intercostal, and lumbar arteries.

The **semispinalis muscle** extends from the loin to the second cervical vertebra. Its fibers separate artificially into a lower portion, semispinalis dorsi, and an upper portion, semispinalis cervicis. The complexus (*semispinalis capitis*) is also considered in this group.

The **semispinalis dorsi muscle** is composed of small, fleshy bellies uniting rather long tendons. It *arises* from the transverse processes of the fifth to the tenth thoracic vertebræ, and is *inserted* into the spines of the upper four thoracic and the lower two cervical vertebræ. It is covered by the longissimus dorsi and the spinalis dorsi muscles and rests upon the multifidus muscle.

Nerve Supply.—From the medial branches of the posterior division of the spinal nerves.

Action.—It is an extensor and lateral flexor of the spinal column.

The **semispinalis cervicis muscle** is thicker and shorter than the semispinalis dorsi. It *arises* from the transverse processes of the upper five or six thoracic vertebræ, and is *inserted* into the spines of the second to the fifth (inclusive) cervical vertebræ. It is covered by branches of the posterior division of the cervical nerves, the princeps cervicis (*descending branch of occipital*), and deep cervical arteries, the deep cervical vein, and the complexus (*semispinalis capitis*) muscle; it rests upon the multifidus muscle.

Nerve Supply.—From the medial branches of the posterior divisions of the spinal nerves.

Action.—It is an extensor and lateral flexor of the cervical portion of the spinal column.

The **levatores costarum muscles** are twelve fan-shaped muscles *arising* from the tips of the transverse processes of the last cervical and all of the thoracic vertebræ except the twelfth, and are *inserted* into the upper border and lateral surface of the next rib below, between the tubercle and the angle. The lower levatores divide into two slips, the additional one passing over one rib to be inserted into the next but one below. They lie lateral to the semispinalis dorsi muscle.

Nerve Supply.—From the intercostal nerves.

Action.—As indicated by their name, they elevate the ribs, thus assisting the external intercostal muscles.

The **multifidus muscle** is situated in the groove at the side of the spinous processes, under the semispinalis, and extends from the axis (*epistropheus*) to the sacrum. The fibers *arise* from the groove on the dorsal aspect of the sacrum, the posterior superior spine of the ilium, the posterior sacro-iliac ligament, and the deep surface of the aponeurotic origin of the erector spinæ (*sacro-spinalis*) muscle. In the lumbar region the fibers *arise* from the mammillary processes; in the thoracic, from the transverse processes, and in the cervical, from the articular processes of the lower four vertebræ. From these numerous points of origin the muscle bundles pass upward in an oblique direction, and are attached to the spinous processes and laminæ of the vertebræ; the more superficial bundles are the longest, and pass to the third or fourth vertebra above their origin; while the deeper ones pass to the next vertebra and to the second or third above.

Nerve Supply.—From the medial branches of the posterior divisions of the spinal nerves.

Action.—It assists in extension and lateral movements of the spine.

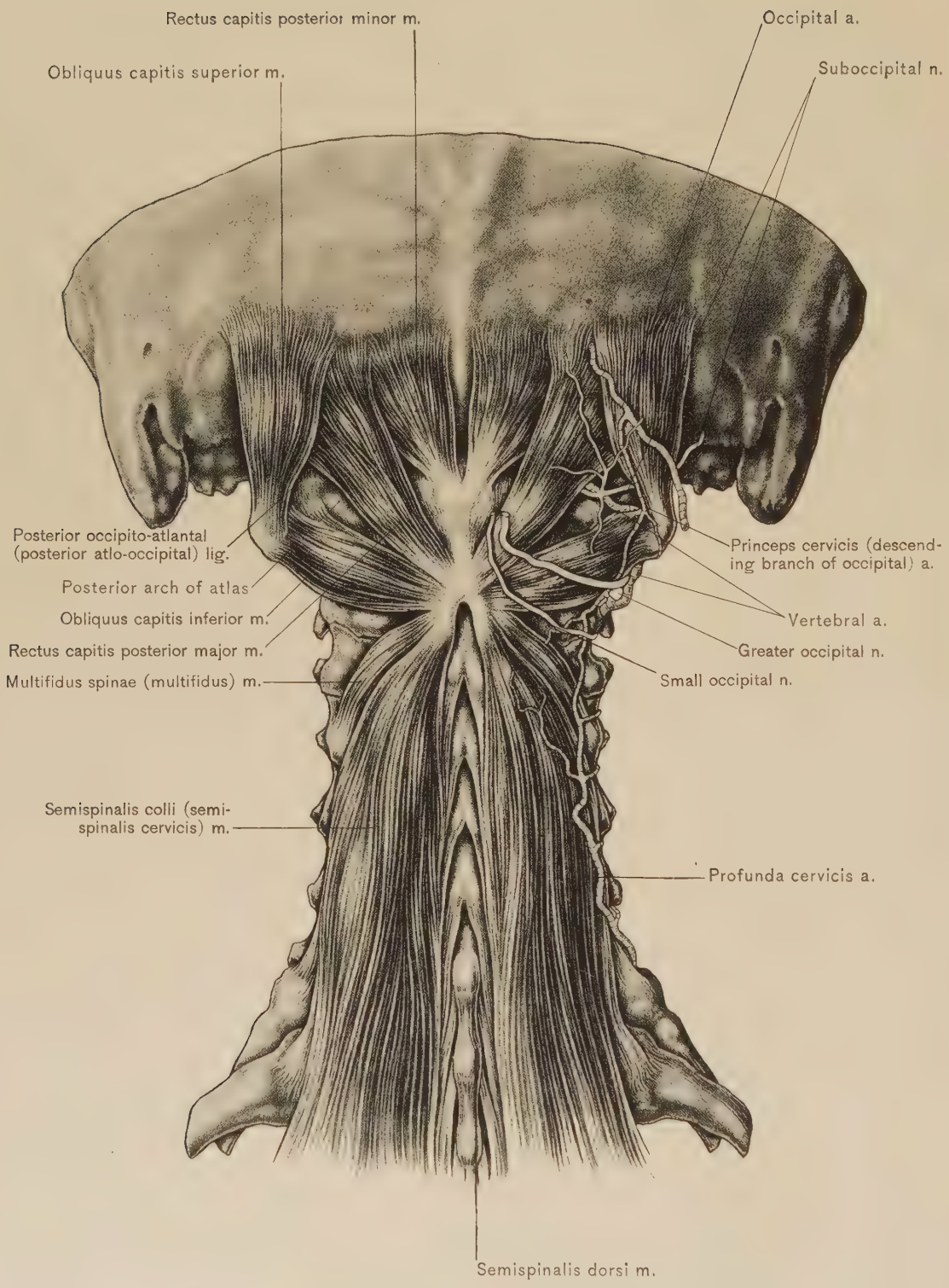
The **rotatores,** situated under the multifidus, are eleven pairs of small quadrilateral **muscles,** each of which *arises* from the superodorsal part of a transverse process of a thoracic vertebra, and ascends to be *inserted* into the inferior margin and lateral surface of the lamina of the vertebra immediately above, extending as far medially as the base of the spinous process.

Nerve Supply.—From the medial branches of the posterior divisions of the spinal nerves.

Action.—These muscles rotate the spinal column, turning the body of the vertebra toward the opposite side, and, acting bilaterally, extend the spinal column.

The **interspinal muscles** extend in pairs between contiguous vertebral spines, the muscles of the two sides being separated by the interspinal ligaments. There are six *cervical* pairs between the axis (*epistropheus*) and the first thoracic vertebra; these are the most distinct. Two or three *thoracic* pairs are sometimes

PLATE CCXXII.



SUBOCCIPITAL TRIANGLE.

found between the first and second thoracic spines above, and the eleventh and twelfth below, and occasionally a pair may be found between the second and third thoracic spines. Four *lumbar* pairs extend between the five lumbar spines, and sometimes a pair extends above the first and below the last lumbar spine.

Nerve Supply.—From the medial branches of the posterior divisions of the spinal nerves.

Action.—They assist, to a slight degree, in extending the spinal column.

The **intertransverse muscles** lie between the transverse processes of adjacent vertebræ. There are seven *pairs of cervical intertransverse* muscles on each side of the spinal column. They are found between the two adjacent anterior and two adjacent posterior tubercles, and are separated by the anterior branch of the cervical nerve emerging from the corresponding intervertebral foramen. They extend from the atlas to the first thoracic vertebra. The *rectus capitis lateralis*, extending between the jugular process of the occipital bone and the transverse process of the atlas, corresponds to an intertransverse muscle.

The *thoracic intertransverse* muscles are found only in the inferior three intervals.

There are four pairs of *lumbar intertransverse* muscles; one muscle of each pair connects the ends of the transverse processes, and the other the accessory tubercle of one vertebra to the mammillary process of the next vertebra below.

Nerve Supply.—From the spinal nerves as they emerge from the intervertebral foramina.

Action.—Lateral flexion of the spinal column.

Movements.—It will be noticed that the muscles which permit movement of the spinal column, or rather which protect it against the effect of too sudden and extensive motion, are diminutive or absent in the thoracic region, the least movable division of the spinal column, and are better developed in the lumbar and cervical regions, where motion is much more free. But in the neck, where the movements are more intricate, these muscles are more numerous, and in the lumbar region they are much larger in order to meet the additional strain due to the greater superimposed weight.

The **posterior cranio-vertebral muscles,** the rectus capitis posterior major and minor and the obliquus capitis superior and inferior together form the suboccipital triangle.

Suboccipital triangle. (Plate CCXXII).—This small, triangular space, exposed by reflection of the complexus (*semispinalis capitis*) and the splenius, is bounded superomedially by the rectus capitis posterior major; superolaterally, by the obliquus capitis superior, and inferiorly, by the obliquus capitis inferior muscles. The roof of the triangle is formed by the complexus (*semispinalis*

capitis) and the splenius muscles, and its floor by the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*) and the posterior arch of the atlas. It contains a small portion of the vertebral artery and the posterior primary division of the first cervical, or suboccipital, nerve. The *vertebral artery* in the suboccipital triangle is seen emerging from the transverse process of the atlas and running above its posterior arch. It leaves the triangle by piercing the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*). The *suboccipital nerve* passes through the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*) and between the vertebral artery and the posterior arch of the atlas. It is small and supplies the posterior recti, the obliqui, and the complexus (*semispinalis capitis*) muscles.

The **rectus capitis posterior major** is a cone-shaped **muscle,** *arising* by its apex from the spine of the axis (*epistropheus*), passing upward, lateralward, and backward, it is *inserted* by its base into the inferior curved (*inferior nuchal*) line of the occipital bone and the surface immediately below it. It is covered by the complexus (*semispinalis capitis*) muscle, and at its insertion, by the obliquus capitis superior muscle; it rests upon the posterior arch of the atlas, the occipital bone, the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*) and the rectus capitis posterior minor muscle.

Nerve Supply.—From a branch of the posterior division of the suboccipital nerve.

Action.—It extends the head and rotates it to the same side.

The **rectus capitis posterior minor muscle,** placed to the medial side of, and overlapped by the preceding muscle, is triangular in shape and *arises* by its apex from the tubercle upon the posterior arch of the atlas and ascends directly upward. It is inserted into the inferior curved (*inferior nuchal*) line of the occipital bone and the surface immediately below it. It is covered by the complexus (*semispinalis capitis*) and the rectus capitis posterior major muscle, and lies upon the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*).

Nerve Supply.—From a branch of the posterior division of the suboccipital nerve.

Action.—It extends the head and assists in lateral movements and rotation of the head.

The **obliquus capitis superior muscle,** also triangular in shape, *arises* by its apex from the back of the upper surface of the transverse process of the atlas, and passes upward and backward to be *inserted* into the occipital bone between the two curved nuchal lines beneath the complexus (*semispinalis capitis*) muscles. It is covered by the complexus (*semispinalis capitis*), the trachelo-mastoid (*longissimus capitis*), and the splenius muscles, and rests upon the rectus capitis

posterior major muscle, the vertebral artery, and the posterior occipito-atlantal ligament (*posterior atlo-occipital membrane*).

Nerve Supply.—From a branch of the posterior division of the suboccipital nerve.

Action—It extends the head, flexes it laterally, and rotates the face to the opposite side.

The **obliquus capitis inferior muscle,** larger than the obliquus capitis superior, *arises* from the spinous process of the axis (*epistropheus*) between the attachments of the rectus capitis posterior major and semispinalis cervicis muscles. It passes almost directly lateralward, and is *inserted* into the tip of the transverse process of the atlas. It is covered by the complexus (*semispinalis-capitis*) muscle and the greater occipital nerve, the latter curving over its lower margin, and rests upon the posterior atlanto-axoid (*atlo-epistropheal*) ligament and the vertebral artery.

Nerve Supply.—From a branch of the posterior division of the suboccipital nerve.

Action.—It rotates the atlas upon the axis (*epistropheus*), carrying the face to the same side.

The **lumbar** (**lumbo-dorsal**) **fascia** is a dense aponeurotic structure, separable into three lamellæ, seen in the space between the last rib and the crest of the ilium. Laterally, all three lamellæ are fused and give origin to the internal oblique and transversalis muscles. It assists in supporting the muscles of the loin. It is attached above to the last rib and the cartilage of the eleventh rib, and below to the posterior third of the crest of the ilium and to the dorsum of the sacrum and the coccyx. The *posterior layer*, which is the strongest of the three, passes behind the erector spinæ (*sacro-spinalis*) muscle and blends with the aponeuroses of the latissimus dorsi and serratus posterior inferior muscles, these aponeuroses being continued upward as the vertebral fascia. This division of the lumbar (*lumbo-dorsal*) fascia is attached to the spines of the lower thoracic, lumbar, and sacral vertebræ. The *middle layer* passes between the erector spinæ (*sacro-spinalis*) and the quadratus lumborum muscles, and is attached to the tips of the transverse processes of the lumbar vertebræ. The *anterior layer* passes in front of the quadratus lumborum, and is attached to the anterior surface of the bases of the transverse processes of the lumbar vertebræ. The upper portion of the anterior layer, which extends between the transverse process of the first lumbar vertebra and the tip and lower border of the last rib, is called the *ligamentum arcuatum externum* (*lateral lumbo-costal arch*). The lower border fuses with the ilio-lumbar ligament. The lumbar (*lumbo-dorsal*) fascia is overlapped to the lateral side of the erector spinæ (*sacro-spinalis*) muscle by the latissimus dorsi

and external oblique muscles. It is an important guide in operations through the loin upon the kidney or the colon.

In lumbar abscess, pointing in Petit's (*lumbar*) triangle, the pus burrows through the middle and posterior lamellæ of the lumbar fascia.

The **nerves of the back** are derived from the posterior primary divisions (*posterior rami*) of the spinal nerves. With the exception of the first and second cervical nerves, the posterior primary are smaller than the anterior primary divisions.

The **posterior primary division (posterior ramus) of the first cervical nerve, or suboccipital,** runs backward, pierces the occipito-atlantal ligament (*atlo-occipital membrane*), passes between the vertebral artery and the posterior arch of the atlas and through the suboccipital triangle. It fails to divide into a medial and a lateral division. It supplies twigs to the rectus capitis posterior major and minor muscles, the obliquus capitis superior and inferior and the complexus (*semispinalis capitis*) muscles. A small branch usually communicates with the greater occipital nerve.

The **posterior primary division (posterior ramus) of the second cervical nerve** is very large and divides into a lateral and a medial branch, the latter being much the larger. It appears between the vertebral arches of the atlas and axis (*epistropheus*). The *lateral branch* sends a twig to the inferior oblique muscle, and then ends in the complexus (*semispinalis capitis*) and the trachelo-mastoid (*longissimus capitis*) muscles. The *medial branch* is called the **greater occipital nerve,** and is the chief cutaneous nerve of the posterior part of the scalp. It sends twigs upward and downward; these communicate with the first and third cervical nerves, forming the *posterior cervical plexus of Cruveilhier.* The greater occipital nerve then ascends, turning upward and backward over the inferior border of the inferior oblique muscle and under cover of the complexus (*semi-spinalis capitis*). It crosses over the suboccipital triangle, pierces the complexus (*semispinalis capitis*) muscle, which it supplies, and the lateral border of the trapezius near the superior curved (*superior nuchal*) line of the occipital bone. It then ramifies in the superficial fascia of the back of the scalp with the occipital artery.

The **posterior division of the third cervical nerve** is smaller than that of the second. Passing backward, it divides into a *lateral branch* which supplies adjacent muscles, and a *medial branch* which is known as the **least (third) occipital nerve.** It pierces the complexus (*semispinalis capitis*), splenius, and trapezius muscles, passes upward, supplying delicate branches to the skin of the neck and the scalp, and communicates with the greater occipital nerve.

The **posterior divisions (posterior rami) of the fourth and fifth cervical nerves** pass backward at the lateral border of the semispinalis cervicis muscle, and

divide into lateral and medial branches. The *lateral branches* supply the splenius, the trachelo-mastoid (*longissimus capitis*), the cervicalis ascendens (*ilio-costalis cervicis*), and the transversalis cervicis (*longissimus cervicis*) muscles. The *medial branches* supply the semispinalis cervicis and the complexus (*semi-spinalis capitis*) muscles, between which they lie, and send branches to the multifidus. They next pass between the complexus (*semispinalis capitis*) muscle and the ligamentum nuchæ, pierce the origin of the trapezius muscle, and are distributed to the integument of the back of the neck.

The *lateral branches* of the posterior divisions of the sixth, seventh, and eighth cervical nerves supply the splenius, the complexus (*semispinalis capitis*), the cervicalis ascendens (*ilio-costalis cervicis*), and the transversalis cervicis (*longissimus cervicis*) muscles. The *medial branches* supply the semispinalis cervicis and the multifidus muscle.

The **posterior primary divisions (posterior rami) of the thoracic nerves** pass backward between the transverse processes of the thoracic vertebræ. They then divide into lateral and medial branches, the former increasing and the latter decreasing in size from the second to the last.

The *lateral branches* of the posterior divisions of the upper six or seven thoracic nerves terminate in the longissimus dorsi and the accessorius (*ilio-costalis dorsi*) muscles. The lower five or six pierce the lateral insertions of the longissimus dorsi, and are then found between that muscle and the accessorius (*ilio-costalis dorsi*). After piercing the latissimus dorsi muscle they reach the integument of the lower lateral aspect of the back.

The *medial branches* supply the longissimus dorsi, the spinalis dorsi, the semispinalis dorsi, the multifidus, the rotatores spinæ, the intertransverse, and the interspinal muscles. The upper six or seven branches pierce the origin of the trapezius muscle and supply the integument.

The **posterior divisions (posterior rami) of the lumbar nerves** also divide into two branches. The *medial branches* end entirely in the multifidus muscle. The *lateral branches* of the upper three lumbar nerves pierce the aponeurosis of the latissimus dorsi near the lateral border of the erector spinæ (*sacro-spinalis*) muscle, cross the crest of the ilium, and are distributed to the integument of the gluteal region. The lateral branches of all five lumbar nerves enter and supply the erector spinæ (*sacro-spinalis*) muscle; the fifth lumbar nerve sends a branch downward, which communicates with the first sacral nerve and helps to form the posterior sacral plexus.

The **posterior primary divisions (posterior rami) of the upper four sacral nerves** emerge at the posterior sacral foramina; the fifth emerges with the dorsal division of the coccygeal nerve through the lower end of the sacral canal.

The **posterior divisions (posterior rami) of the upper three sacral nerves** divide into lateral and medial branches, while the lower two sacral and the coccygeal nerve remain undivided. The *lateral branches* of the posterior divisions of the upper three sacral nerves unite with each other and with the lateral branch of the last lumbar nerve over the sacrum, and the great sacro-sciatic (*sacro-tuberous*) ligament to form a series of loops—the *posterior sacral plexus*. From these loops are derived two or three nerves which pierce the gluteus maximus muscle to supply the integument. The *medial branches* of the posterior divisions of the upper three sacral nerves supply the multifidus muscle. The posterior divisions of the lower two sacral nerves form loops with the coccygeal nerve and the posterior branch of the third sacral nerve. Branches from these loops supply the skin over the coccyx.

LIGAMENTS OF THE VERTEBRAL COLUMN

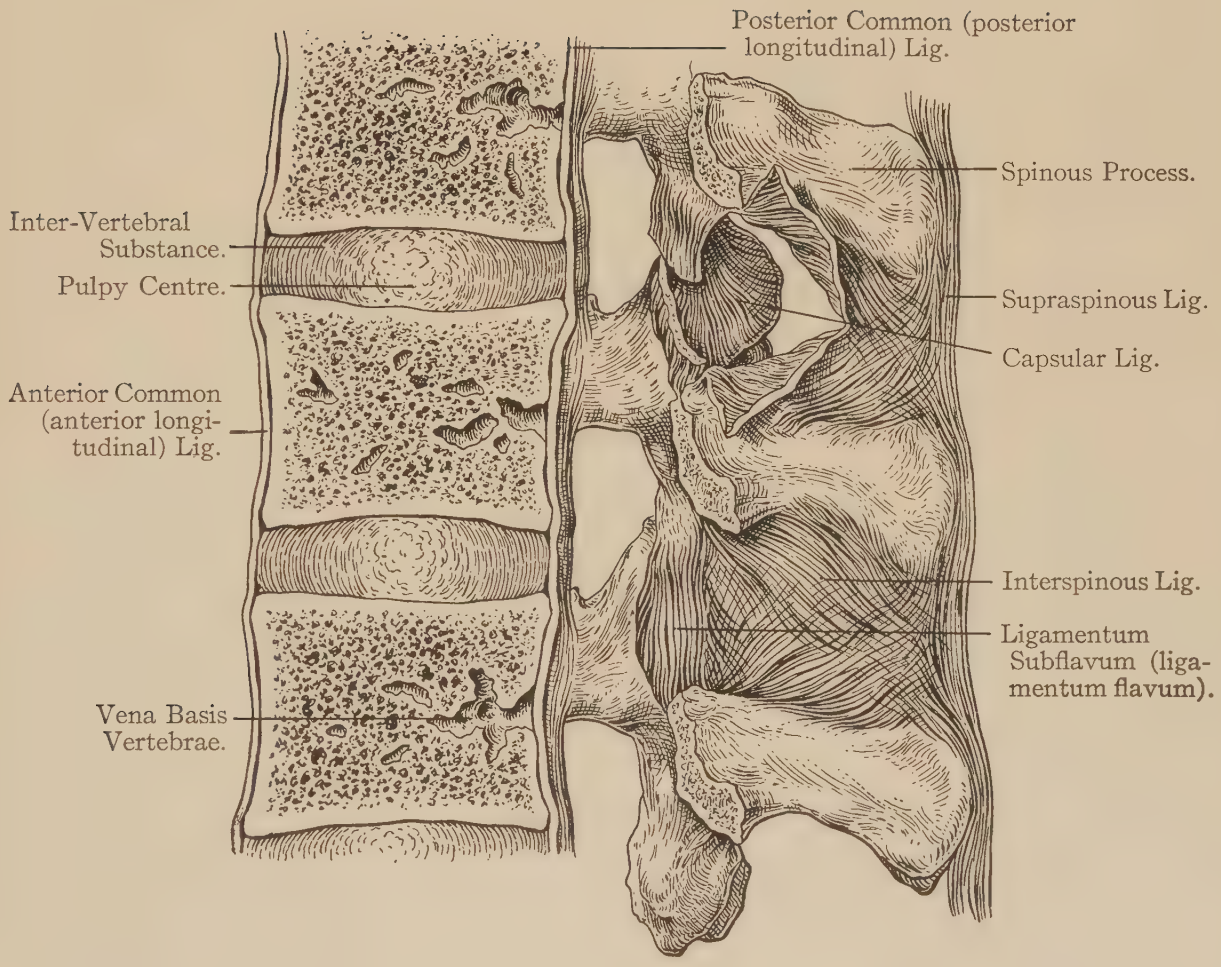
The ligaments uniting the vertebræ may be divided into those that connect the bodies; the laminæ; the spinous processes; the transverse processes, and the articular processes of the vertebræ.

The **Ligaments which Unite the Bodies of the Vertebræ** are the anterior and posterior common (*longitudinal*) ligaments, the intervertebral discs (*intervertebral fibrocartilages*), and the lateral, or short, vertebral ligaments (Plate CCXXIII).

The **anterior common (longitudinal) ligament** is a fibrous band which is situated upon the anterior surface of the bodies of the vertebræ, and extends from the tubercle upon the anterior arch of the atlas to the front of the middle piece of the sacrum. Above, it is narrow and forms the central portion of the atlo-axoid (*atlo-epistropheal*) ligament. As it descends it broadens and forms a glistening white investment for the anterior surface of the bodies of the vertebræ. Below, it is attached to the front of the sacrum, and is lost in the periosteum of that bone. It is continued as the *anterior sacro-coccygeal* ligament. The ligament is composed of numerous fibers of various lengths. The superficial fibers extend over four or five consecutive vertebræ, the deeper ones over two or three vertebræ, and the deepest ones connect adjacent vertebræ, but all the fibers are so interlaced that it is impossible to separate the ligament into the three sets of fibers. The ligament is closely attached to the intervertebral discs (*intervertebral fibrocartilages*) and the edges of the bodies of the vertebræ, but none of the fibers is attached to the intermediate portion of the bodies. It is thicker in the lumbar than in the cervical region, and thickest in the thoracic region.

The **posterior common (longitudinal) ligament** is located upon the posterior surface of the bodies of the vertebræ and lines the anterior wall of the vertebral

PLATE CCXXIII.



LIGAMENTS OF VERTEBRAL COLUMN.

canal. It extends from the basilar groove of the occipital bone to the coccyx, and is broader above than below, being thickest in the thoracic region; lateral expansions opposite the intervertebral discs (*intervertebral fibrocartilages*) give it a dentated appearance. Between the ligament and the middle of the posterior surface of the bodies of the vertebræ are intervals which are occupied by some areolar tissue and vessels which supply the bodies of the vertebræ. The more superficial fibers extend between three or four vertebræ, and the deeper ones between adjacent vertebræ.

The **intervertebral discs** (**intervertebral fibrocartilages**) form a series of fibrocartilages, situated between the adjacent surfaces of the bodies of the vertebræ from the axis (*epistropheus*) to the sacrum, and constitute the chief bond of union between the vertebræ. In the sacral region they are more or less completely ossified. Their flattened or somewhat wedge-shaped outline corresponds to that of the adjacent vertebral bodies. In the thoracic region their thickness is nearly uniform, the thoracic curve being chiefly formed by the bodies of the vertebræ, while in the cervical and lumbar regions they are thicker anteriorly, and thus form the curves of the spinal column at these points. The proportion of the discs varies in the different regions of the spine, although their absolute thickness is greatest in the lumbar region, while they are relatively largest in the cervical region. When the discs are shrunken or compressed, as in old persons and laborers, the spinal column shortens and bends forward. They are composed of a firm ring of fibrocartilaginous tissue and a central pulpy substance (*nucleus pulposus*). The fibrocartilaginous tissue is arranged in concentric laminæ, the fibers of which pass obliquely from one surface of the disc to the other. The directions of the fibers of the two adjacent laminæ are not parallel, but form angles like the limbs of the letter X. The central substance of the discs is of a pulpy consistency, and is composed of a fine connective-tissue matrix which contains cartilage cells in its meshes.

The **lateral, or short, vertebral ligaments** connect the adjacent margins of the bodies of the vertebræ in the interval between the anterior and posterior common (*longitudinal*) ligaments, with which they are continuous. They are better developed in the thoracic and lumbar regions than in the cervical region.

The **Laminæ** are connected by the **ligamenta subflava** (**ligamenta flava**) which consist of thick plates of yellow elastic tissue found in the spaces between the laminæ of the vertebræ. The first of these ligaments extends from the axis (*epistropheus*) to the third cervical vertebra, the two spaces above being filled by the posterior occipito-atlantal ligament (*atlo-occipital membrane*) and posterior atlanto-axoid (*posetrior atlo-epistropheal*) ligament. The ligamenta subflava (*ligamenta flava*) are attached superiorly to the anterior surfaces of the inferior

articular processes and the lower margins of the laminæ of the vertebræ; inferiorly, to the anterior surfaces of the superior articular processes and the superior margins of the laminæ. Each ligament extends from the articular processes of one side to those of the opposite side, forming one broad, short ligament. These ligaments assist in forming the capsular ligaments (*articular capsules*) which connect the articular processes and are continuous with the interspinal ligaments at the roots of the spinal processes. They are stronger in the thoracic than in the cervical region, and strongest in the lumbar region. They assist in retaining the spinal column in the erect position.

The **Spinal Processes** are connected by the supraspinal and interspinal ligaments.

The **supraspinal ligaments** connect the tips of the spinal processes, and present the appearance of a strong, narrow, continuous band extending from the seventh cervical vertebra (vertebra prominens) to the spinal processes of the sacrum. They are continued upward as the ligamentum nuchæ and downward along the spines of the sacrum. The downward continuation of the supraspinal ligaments closes the lower end of the spinal canal, and is attached to the back of the coccyx.

The **interspinal ligaments** are thin, membranous sheets which connect adjacent spinal processes of the vertebræ. They are strongest in the lumbar and weakest in the cervical region where they are supported by the *interspinal* muscles. The fibers of each interspinal ligament interlace obliquely, springing from the tips of two adjacent spinal processes and radiating to their opposite margins. They extend from the ligamenta subflava (*ligamenta flava*) to the supraspinal ligament.

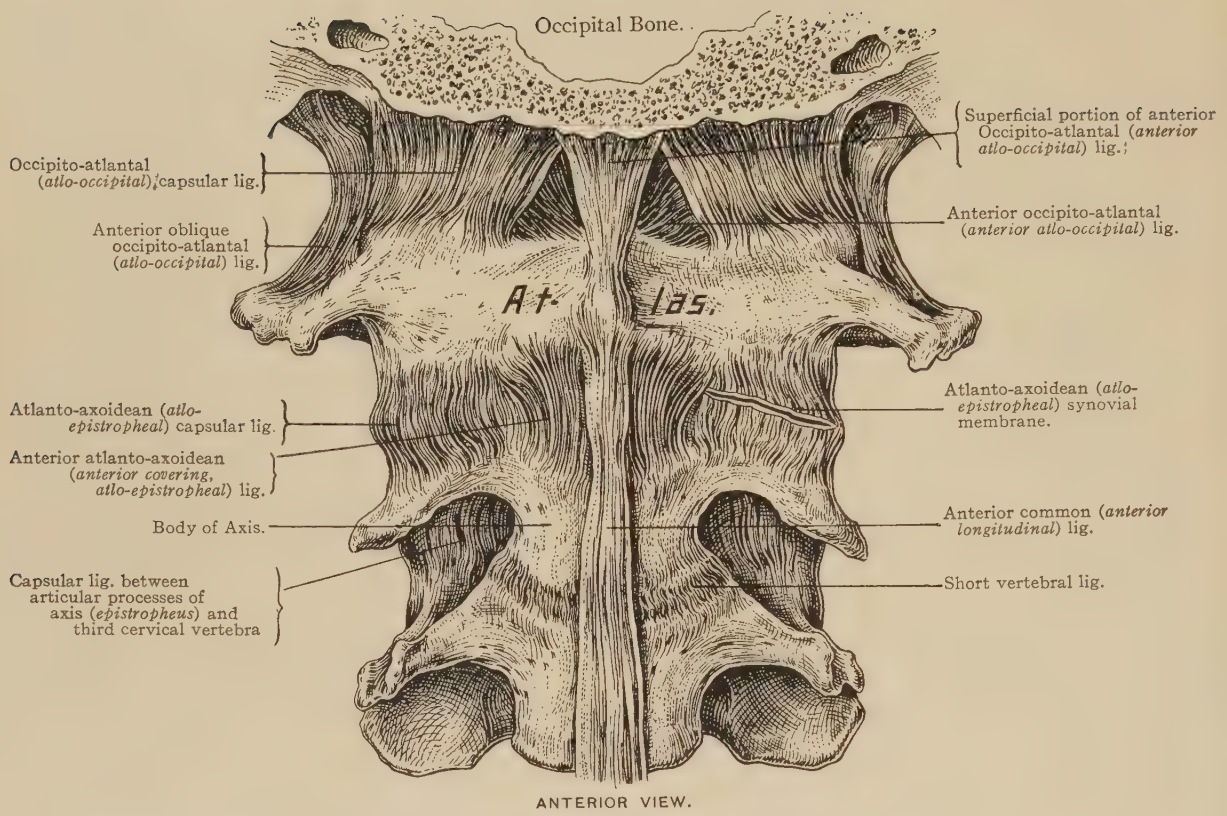
The **Transverse Processes** are connected by the intertransverse ligaments.

The **intertransverse ligaments** consist of weak fibers that pass between the tips of the transverse processes, varying in form and size. They are best developed in the lower thoracic region where they appear as weak bands; in the lumbar region they are membranous, while in the cervical and upper thoracic regions they are either poorly developed or are entirely absent, being replaced by the intertransverse muscles.

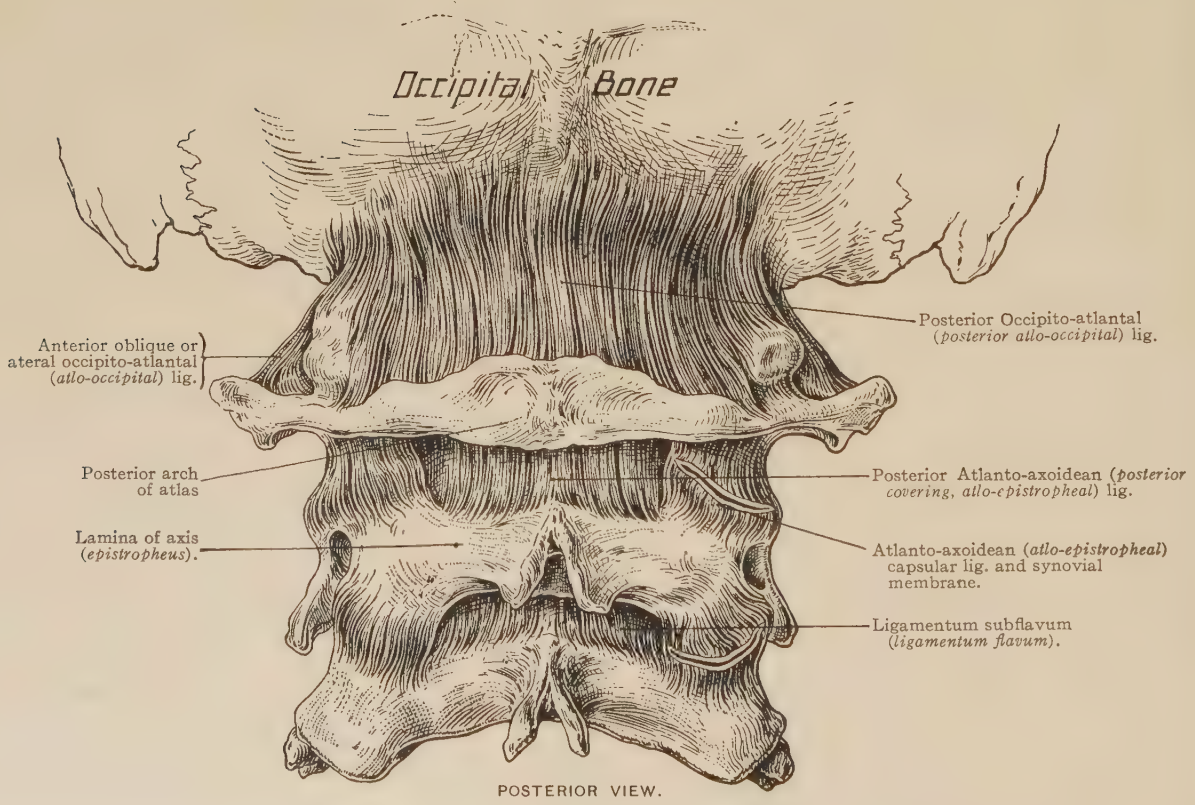
The **Articular Processes** are connected by capsular ligaments.

The **capsular ligaments** (**articular capsules**) connect adjacent articular processes and are attached along the margins of the articulating surfaces. Their medial portion is formed by the lateral part of the ligamenta subflava (*ligamenta flava*). They are loose in the cervical region; in the thoracic region they are short and tight, while in the lumbar region they again are lax. Each joint is lined by a synovial membrane.

PLATE CCXXIV.


Occipital Bone.
Superficial portion of anterior Occipito-atlantal (*anterior atlo-occipital*) lig.
Occipito-atlantal (*atlo-occipital*) capsular lig.
Anterior occipito-atlantal (*anterior atlo-occipital*) lig.
Anterior oblique occipito-atlantal (*atlo-occipital*) lig.
At. las.
Atlanto-axoidean (*atlo-epistropheal*) synovial membrane.
Atlanto-axoidean (*atlo-epistropheal*) capsular lig.
Anterior atlanto-axoidean (*anterior covering, atlo-epistropheal*) lig.
Anterior common (*anterior longitudinal*) lig.
Body of Axis.
Capsular lig. between articular processes of axis (*epistropheus*) and third cervical vertebra
Short vertebral lig.

ANTERIOR VIEW.


Occipital Bone
Posterior Occipito-atlantal (*posterior atlo-occipital*) lig.
Anterior oblique or ateral occipito-atlantal (*atlo-occipital*) lig.
Posterior arch of atlas
Posterior Atlanto-axoidean (*posterior covering, atlo-epistropheal*) lig.
Lamina of axis (*epistropheus*).
Atlanto-axoidean (*atlo-epistropheal*) capsular lig. and synovial membrane.
Ligamentum subflavum (*ligamentum flavum*).

POSTERIOR VIEW.

OCCIPITO-ATLANTAL (ATLO-OCCIPITAL) AND ATLANTO AXOIDEAN (ATLO-EPISTROPHEAL) LIGAMENTS.

Movements.—The spinal column is the axis of the skeleton; it supports the cranium, the upper extremities, and part of the trunk, and is supported by the pelvis and the lower extremities. It is composed of a number of bones, one superimposed upon the other and bound together by numerous strong ligaments. When assisted by the surrounding muscles it is capable of sustaining great weight. By means of their elasticity the intervertebral discs (*intervertebral fibrocartilages*) diminish or prevent the transmission of shock. The bodies and intervening discs are the chief supports of the superimposed weight, and the articular processes, assisted by the ligaments between the spines and between the transverse processes, steady the column. Although the vertebræ are firmly united and there is little movement between adjacent vertebræ, the spinal column is quite flexible and capable of various movements, made possible by the elasticity of the intervertebral substance. All movements occur around an axis which passes through the central pulpy substance of the intervertebral discs (*intervertebral fibrocartilages*). The movements vary in different regions, their freedom differing with the shape of the bodies and of the articular, transverse, and spinal processes. The movements are flexion, extension, lateral flexion, circumduction, and rotation.

In the **cervical region** there is little movement between the axis (*epistropheus*) and the third cervical vertebra, but below this vertebra all movements are free in this region. Extension is freer, while flexion is more limited than in the lumbar region.

In the **thoracic region** lateral flexion is limited. There is a considerable amount of rotation, especially in the upper part of this region where combined lateral flexion and rotation or torsion may take place.

In the **lumbar region** forward and backward flexion is free, especially the former motion. Rotation is not possible, but a combination of forward, backward, and lateral flexion permits a certain amount of circumduction.

The joints between the occipital bone, the atlas, and the axis (*epistropheus*), differ in form from those of the intervertebral joints below, and thus require separate description.

The **Axis (Epistropheus) is Connected with the Atlas** by the anterior and posterior atlanto-axoid (*atlo-epistropheal*), two capsular, transverse, and the odontoid ligaments, and by two lateral and one central atlanto-axoid (*atlo-epistropheal*) joint (Plate CCXXIV).

The **anterior atlanto-axoid (atlo-epistropheal) ligament** is a thin, fibro-elastic membrane, attached above to the anterior surface and lower border of the anterior arch of the atlas, and below to the base of the odontoid process (*dens*) and the transverse ridge on the front of the body of the axis (*epistropheus*). Its median portion is covered by the narrow upper end of the anterior common

(*longitudinal*) ligament which, in this location, is sometimes called the **superficial anterior atlanto-axoid** (*atlo-epistropheal*) **ligament.** On each side, the atlanto-axoid (*atlo-epistropheal*) ligament is continuous with the capsular ligaments. It is covered by the longus colli muscles.

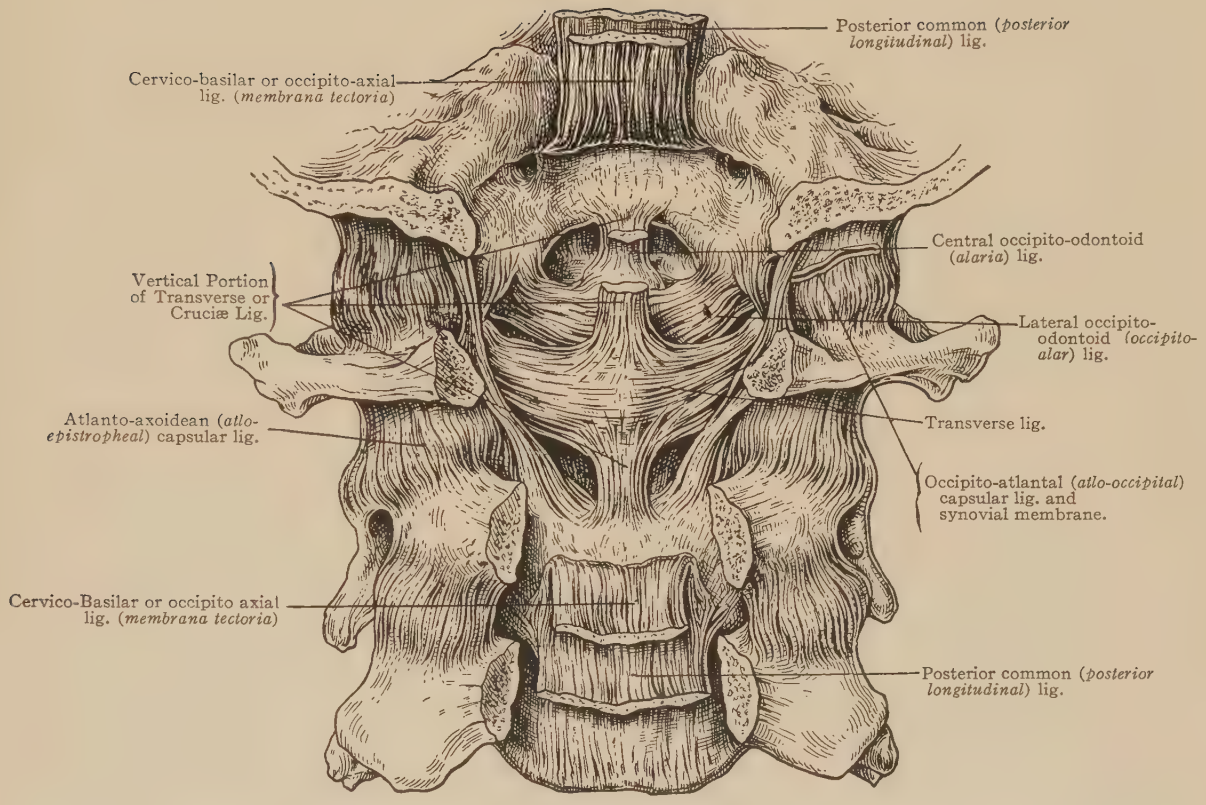
The **posterior atlanto-axoid** (**atlo-epistropheal**) **ligament** is a thin membrane which takes the place of the ligamenta subflava (*ligamenta flava*) in this location, although it is much more fibrous and less elastic than the latter. It is attached above, to the posterior surface and lower margin of the posterior arch of the atlas and below, to the dorsal aspect of the superior margins of the lamina of the axis (*epistropheus*). Laterally, it extends to the posterior roots of the transverse processes, and is continuous with the capsular ligaments. It is covered by the rectus capitis posterior major and obliquus capitis inferior muscles.

The **lateral atlanto-axoid** (**atlo-epistropheal**) **joints** are formed by the articulation of the superior articular processes of the axis (*epistropheus*) with the inferior articular surface of the lateral mass of the atlas. Each joint has a loose *capsular ligament* and one synovial sac. The ligaments are strengthened anteriorly and posteriorly by the anterior and posterior atlanto-axoid ligaments (*atlo-epistropheal membrane*).

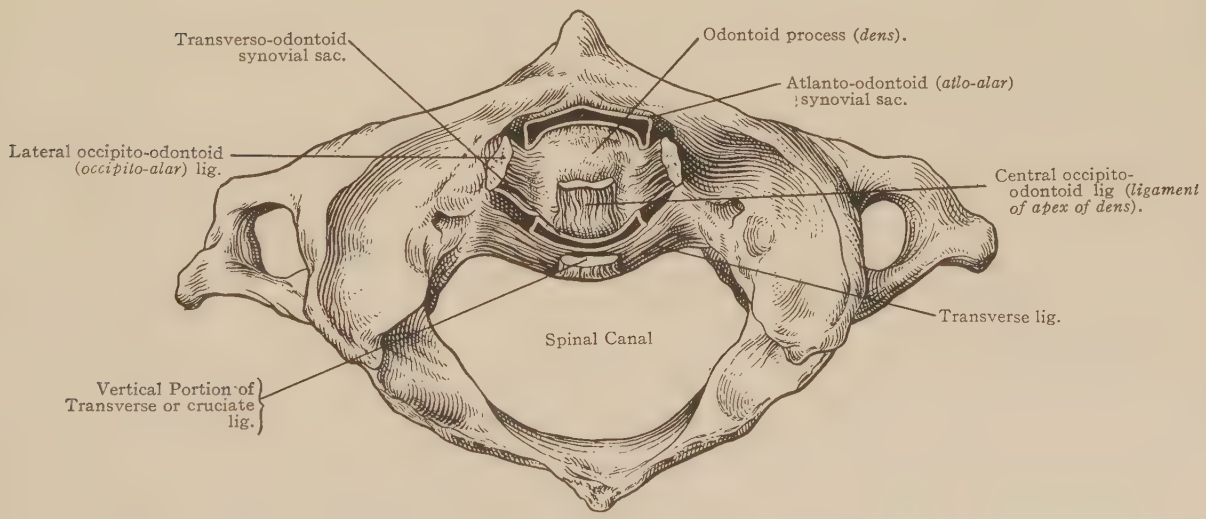
The **central atlanto-axoid** (**atlo-epistropheal**) **joint** (Plate CCXXV) divides into two joints—one between the odontoid process (*dens*) of the axis (*epistropheus*) and the transverse ligament (syndesmo-odontoid) and the other between the odontoid process and anterior arch of the atlas (atlanto-odontoid). Each of these joints has a synovial membrane. The synovial sac of the syndesmo-odontoid joint is limited by a fibrous membrane which passes from the transverse ligament to the margins of the articular facet upon the posterior surface of the odontoid process (*dens*), and thus forms a *capsular ligament.* This synovial sac often communicates with the atlanto-occipital synovial sacs. The synovial sac of the atlanto-odontoid joint is supported by the atlanto-odontoid capsular ligament, which passes between the margins of the articular surface upon the anterior aspect of the odontoid process (*dens*) and those of the articular surface upon the internal surface of the anterior arch of the atlas. The atlanto-odontoid capsular ligament is continuous with the atlanto-occipital capsular ligaments. At the margins of the arch of the atlas it blends with the central occipito-odontoid ligament (*ligamentum apicis dentis*), the anterior atlanto-occipital ligament (*anterior atlo-occipital membrane*), and the anterior atlanto-axoid ligament (*atlo-epistropheal membrane*).

The **transverse ligament of the atlas,** the most important constituent of the ligamentum transversum, is a strong, closely woven, fibrous band which passes across the large central opening in the arch of the atlas, and divides it into a small

PLATE CCXXV.


Posterior common (*posterior longitudinal*) lig.
Cervico-basilar or occipito-axial lig. (*membrana tectoria*)
Central occipito-odontoid (*alaria*) lig.
Vertical Portion of Transverse or Cruciæ Lig.
Lateral occipito-odontoid (*occipito-alar*) lig.
Atlanto-axoidean (*atlo-epistropheal*) capsular lig.
Transverse lig.
Occipito-atlantal (*atlo-occipital*) capsular lig. and synovial membrane.
Cervico-Basilar or occipito axial lig. (*membrana tectoria*)
Posterior common (*posterior longitudinal*) lig.

LIGAMENTS IN POSTERIOR SURFACE OF UPPER PART OF ANTERIOR WALL OF SPINAL CANAL.


Transverso-odontoid synovial sac.
Odontoid process (*dens*).
Atlanto-odontoid (*atlo-alar*) synovial sac.
Lateral occipito-odontoid (*occipito-alar*) lig.
Central occipito-odontoid lig (*ligament of apex of dens*).
Transverse lig.
Spinal Canal
Vertical Portion of Transverse or cruciate lig.

CENTRAL ATLANTO-AXOID (ATLO-EPISTROPHEAL) JOINT.

anterior portion, through which the odontoid process (*dens*) projects, and a large posterior part, which is the upper continuation of the spinal canal and transmits the spinal cord, its membranes, and the spinal portion of the spinal accessory (*accessory*) nerves. Upon each side, the transverse ligament is attached to the tubercle upon the medial surface of the lateral mass of the atlas. From the middle of the transverse ligament a band passes upward to the posterior surface of the basilar part of the occipital bone, and another passes downward to the body of the axis (*epistropheus*), these bands together with the transverse ligament forming a **cruciate ligament.** The anterior surface of the transverse ligament is smooth and in relation with the syndesmo-odontoid synovial membrane. The lower margin of the ligament is closely apposed to the neck of the odontoid process (*dens*) and thus firmly suspends that process in place.

Movements.—The movements between the atlas and axis (*epistropheus*) are necessarily chiefly in a rotatory direction. These movements are limited by the occipito-axoid, or check, ligament (*membrana tectoria*) and the atlanto-axoid (*atlo-epistropheal*) ligament. The movement in the lateral atlanto-axoid (*atlo-epistropheal*) joints is of a gliding character; there is also slight anteroposterior and lateral flexion.

The **Ligaments which Connect the Axis (Epistropheus) with the Occipital Bone** are the occipito-axoid (*membrana tectoria*), the cruciate, and the three odontoid ligaments (Plate CCXXV).

The **occipito-axoid ligament** (**membrana tectoria**) is the upper portion of the posterior common ligament, some of the fibers of which are not attached to the axis (*epistropheus*) but pass upward to theo ccipital bone. The ligament is attached below to the posterior surface of the body of the axis (*epistropheus*), from the root of the odontoid process (*dens*) downward, its lower attachment also extending to the upper part of the body of the third cervical vertebra. Above, it is attached to the basilar groove of the occipital bone. It is narrow at the body of the axis (*epistropheus*) and gradually broadens above. It is in relation in front with the cruciate ligament, and behind with the dura mater of the spinal cord, and is exposed by removing the spines and laminæ of the atlas and axis (*epistropheus*).

The **cruciate ligament of the atlas** is described with the transverse ligament (see above).

The three **odontoid ligaments** connect the odontoid process (*dens*) with the occipital bone.

The *middle odontoid, or suspensory, ligament,* (*ligamentum apicis dentis*) is attached below to the tip of the odontoid process (*dens*), and above to the inferior surface of the anterior margin of the foramen magnum. It is a slender band

which is located between the two lateral odontoid ligaments (*ligamenta alaria*). It is in relation in front with the anterior atlanto-occipital, and behind with the upper division of the cruciate ligament.

The two *lateral odontoid, or check, ligaments* (*ligamenta alaria*) are strong, rounded bands which pass almost transversely lateralward and slightly upward from the sides of the apex of the odontoid process (*dens*) to the rough depressions upon the medial surfaces of the condyles of the occipital bone.

The **Ligaments which Connect the Atlas with the Occipital Bone** are: the anterior and posterior atlanto-occipital ligaments (*atlo-occipital membranes*), two capsular, and two lateral atlanto-occipital ligaments (*atlo-occipital membranes*).

The **anterior atlanto-occipital ligament** (**anterior atlo-occipital membrane**) is attached below to the upper margin of the anterior arch of the atlas, and above to the anterior margin of the foramen magnum. Its central portion is thick and strong, and is the upward continuation of the anterior common (*anterior longitudinal*) ligament. The lateral portions of the ligament are thinner, and continuous with the capsular ligaments. It is covered in front by the rectus capitis anterior minor muscles. Behind it are the odontoid ligaments (*ligamenta alaria and apicis dentis*).

The **posterior atlanto-occipital ligament** (**posterior atlo-occipital membrane**) is a thin membrane and corresponds to the ligamenta subflava (*ligamenta flava*), but contains no elastic tissue. Its laxity, however, permits free motion. The ligament is attached below to the posterior surface and upper margin of the posterior arch of the atlas, and above to the posterior margin of the foramen magnum from one condyle to the other. Upon each side of its inferolateral portion an opening close to the arch of the atlas gives passage to the vertebral artery and the suboccipital nerve. In front, the ligament is in relation with the dura mater, and behind, with the rectus capitis posterior minor and the obliquus capitis superior muscles.

The **two capsular ligaments** are attached above to the margins of the condyles of the occipital bone, and below to the margins of the articular surfaces upon the superior aspect of the lateral mass of the atlas. These ligaments are lax and not very strong, and therefore do not add much strength to the joint. Each capsular ligament is lined with a synovial membrane which occasionally communicates with the synovial sac of the transverse odontoid joint.

The **lateral, or anterior oblique, atlanto-occipital ligaments** (*lateral atlo-occipital membranes*) are two strong fibrous bands placed upon the front of the lateral surface of the capsular ligament. They pass from the bases of the transverse processes of the atlas forward and upward, to be attached to the jugular processes of the occipital bone.

Movements.—The altanto-occipital articulations permit backward and forward gliding motion, thus giving a limited nodding movement to the head. In more extensive forward and backward movements of the head the cervical portion of the spinal column is flexed and extended. There is also a very slight transverse and oblique gliding movement.

Blood Supply.—The blood supply of the spinal column and its articulations is derived from the vertebral, occipital, ascending pharygneal, ascending cervical, intercostal, lumbar, ilio-lumbar, medial sacral, and lateral sacral arteries.

Nerve Supply.—From the spinal nerves.

Fractures and dislocations of the vertebra are most common in the cervical and lumbar regions where mobility of the spinal column is greatest. These fractures are discussed with fractures of the spinal cord, at p. 425.

Dissection.—Having finished the study of the muscles of the back, the student should thoroughly clean the posterior aspect of the vertebræ from the skull to the base of the sacrum. In removing the muscles, care must be taken to avoid destroying the posterior divisions of the spinal nerves which supply them. The posterior wall of the spinal canal should then be removed in one piece. To accomplish this, place the body upon the table, face downward, with the head hanging over the edge, and a block under the abdomen; saw through the laminæ of the vertebræ on each side close to the bases of the spinous processes from the third cervical to the last lumbar, inclusive. The ligaments between the spinous processes and between the laminæ of the second and third cervical, and the last lumbar and first sacral vertebræ, should be divided with the knife, and the posterior wall of the canal lifted out. This will expose a quantity of loose areolar tissue and fat which contains plexuses of veins and some small arteries. Carefully remove the areolar tissue and fat.

The Spinal Arteries.—The blood supply of the spinal column, the spinal ligaments, the periosteum, and the spinal cord and its membranes is derived from the spinal arteries which enter the canal through the intervertebral foramina. The spinal arteries in the cervical region are derived from the vertebral, the ascending cervical, the deep cervical, and the occipital arteries; in the thoracic region, from the dorsal branches of the intercostal arteries; in the lumbar region, from the posterior branches of the lumbar arteries, and in the sacral region, from the lateral sacral arteries. After entering the spinal canal each spinal artery divides into three branches: one, the postcentral, passes to the vertebral arches and the ligamenta subflava (*ligamenta flava*); another, the neural, pierces the dura mater above the corresponding spinal nerve, and supplies the spinal cord and its membranes, and the third, the prelaminar, passes to the posterior surface of the bodies of the vertebræ. The small plexuses of arteries seen on the

posterior aspect of the bodies of the vertebræ are formed by the divisions of the third set of branches which anastomose with each other. These plexuses also give off branches which pass anteriorly around the wall of the canal to join branches from a median artery found on the posterior surface of the anterior common (*longitudinal*) ligament.

The **Veins Found Within the Spinal Canal** (Plate CCXXVI) are the meningo-rachidian and the medulli-spinal veins. The **meningo-rachidian veins** lie in the extra-dural fat, and are arranged in two plexuses—one anterior and one posterior. The anterior plexus (*anterior longitudinal vertebral sinuses*) cannot be studied until the spinal cord and its membranes have been removed from the spinal canal. It consists of two longitudinal veins which communicate freely with each other by means of transverse veins which pass beneath the posterior common (*posterior longitudinal*) ligament, and receive the veins from the bodies of the vertebræ (venæ basis vertebræ). The anterior plexus (*anterior longitudinal vertebral sinuses*) communicates with the basilar sinus. Near the arch of the atlas it gives off a branch which forms the origin of the vertebral vein. Other branches are given off near the intervertebral foramina, and accompany the spinal nerves. The *posterior longitudinal plexus* consists of two longitudinal veins, or channels, placed upon the medial surface of the laminæ. Branches pass freely from one channel to the other; others pierce the ligamenta subflava (*ligamenta flava*) to communicate with the dorsi-spinal veins, while other branches pass forward to join the anterior plexus (*anterior longitudinal vertebral sinuses*), thus forming a network which entirely encircles the spinal cord. The posterior plexus (*posterior longitudinal vertebral sinuses*) communicates with the occipital sinus.

The **medulli-spinal veins** are described with the spinal cord.

THE SPINAL CORD

The spinal cord (**spinal medulla**) (Plate CCXXVII) occupies the upper two-thirds of the vertebral canal, and is a direct continuation of the medulla oblongata. It extends from the lower border of the foramen magnum (below the decussation of the pyramids of the medulla) to the level of the upper border of the body of the second lumbar vertebra; near its termination, it assumes a conical shape, the **conus medullaris,** and terminates in a slender thread, the **filum terminale.** In the fetus, up to the third month, the cord extends the entire length of the spinal canal, but due to the more rapid and continuous growth of the vertebral column, the cord soon ceases to occupy the entire canal. At birth it extends only to the third lumbar vertebra. The length of the spinal cord in the adult varies from forty to fifty centimeters (sixteen to twenty inches), with an average weight

PLATE CCXXVI.

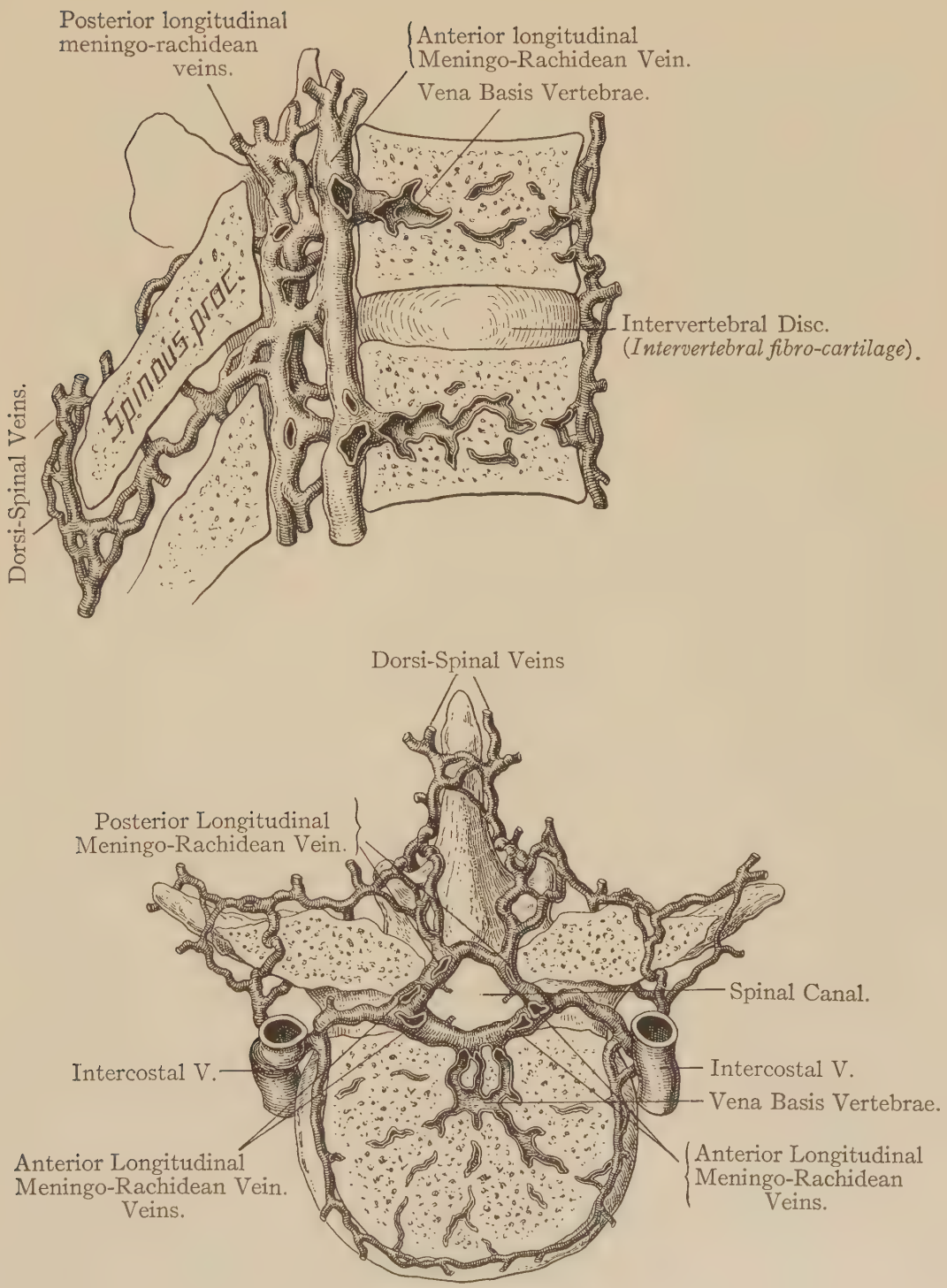
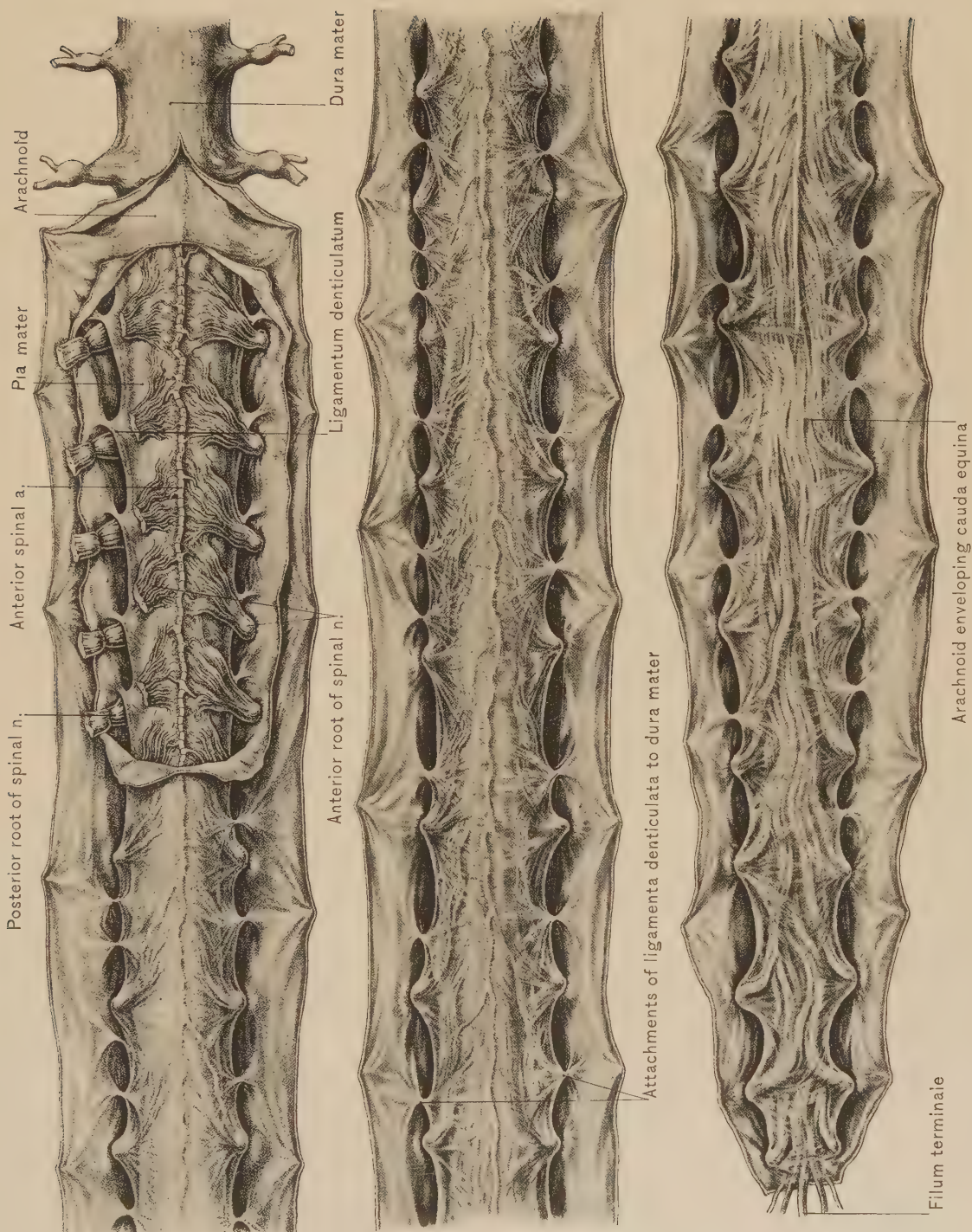


PLATE CCXXVII.



SPINAL CORD AND MEMBRANES.

of about 28 grams (one ounce). It is a somewhat flattened cylinder, wider in its transverse diameter; in the thoracic region, however, it is almost cylindrical. Lodged as it is in the spinal canal, it follows the curves of the spinal column. It presents a **cervical enlargement** between the third cervical and the second thoracic vertebra, and a **lumbar enlargement** between the ninth thoracic and first lumbar vertebræ. The former enlargement is widest opposite the sixth cervical, and the latter opposite the twelfth thoracic vertebra. These enlargements occur where the large nerves are given off to supply the extremities.

The Membranes of the Spinal Cords.—The membranes, or meninges, of the spinal cord are the dura mater, the arachnoid, and the pia mater. They are continuous with the corresponding membranes of the brain, and hold the same relation to each other as those of the brain.

The **dura mater** is a non-adherent, dense, fibrous sheath which surrounds the spinal cord. The periosteum which lines the spinal canal is continuous with, and represents the periosteal layer of the dura mater of the brain, while the extra-dural (meningo-rachidian) veins of the spinal canal correspond in position to the sinuses of the dura mater of the brain. The dura mater is separated from the walls of the spinal canal by an imaginary space, the *cavum epidurale*, occupied by loose areolar tissue, fat, and the anterior and posterior plexuses (*longitudinal sinuses*) of the extra-dural veins. The spinal dura extends from the lower margin of the foramen magnum to the base of the coccyx, where it blends with the periosteum. As an enveloping membrane it exists only as far as the third sacral vertebra; beyond this, it is impervious and is only a slender cord which surrounds the filum terminale. It is attached above to the margin of the foramen magnum, to the axis (*epistropheus*), and to the third cervical vertebra; below, it is firmly anchored and held in place by its attachment to the periosteum of the posterior surface of the base of the coccyx.

Dissection.—Remove the spinal cord and its membranes by dividing the medulla oblongata and membranes of the cord at the foramen magnum, and the spinal nerves as far lateralward in the intervertebral foramina as possible, so as to preserve the ganglia on their posterior roots. A perfectly fresh cord should be hardened before its membranes are removed; but if soft, it can be dissected under water, which will protect it from pulpefaction. Incise the dura mater near its termination and open it along its posteromedial surface with a pair of blunt scissors, being careful to avoid injuring the subjacent arachnoid. Reflect the dura mater laterally, and note the shining, inner surface, the **subdural space**, which lies between the dura mater and the arachnoid and is prolonged for a short distance upon the roots of the spinal nerves. Note that each spinal nerve as it leaves the cord is enveloped by a separate tubular prolongation of

the dura mater, and that the anterior and posterior roots of the nerves are separated by a septum.

The arachnoid.—The arachnoid is a thin, veil-like membrane between the dura and the pia mater. It is more delicate than the arachnoid of the brain, but resembles it in sending tubular prolongations along the nerves. It is attached posteriorly to the dura mater by prolongations of connective tissue. Below, it is prolonged upon the cauda equina.

The arachnoid forms a long sac, the cavity of which lies between the arachnoid and the pia mater, and is known as the **subarachnoid space.** It contains the greater part of the cerebro-spinal fluid, and is continuous with the subarachnoid space of the brain. This space can be demonstrated by inflating it with air through a blow-pipe inserted near the foramen magnum. This will illustrate the condition found in the congenital defect known as spina bifida, in which there is an overabundance of cerebro-spinal fluid with faulty development of the posterior wall of the lumbar portion of the spinal canal. In this condition the membranes are pushed through the opening in the spinal canal by the weight of the cerebro-spinal fluid, which occupies the space now containing air.

Through the foramen magnum the subarachnoid space of the spinal cord communicates with the subarachnoid space of the brain, and the latter, through three openings in the posterior part of the fourth ventricle (foramina of Magendie, Key, and Retzius), communicates with the ventricles of the brain.

Dissection.—Incise the arachnoid and reflect it from the underlying pia mater. This will open the subarachnoid space, which has just been inflated. It will be seen that the arachnoid is attached to the pia mater by numerous trabeculæ of subarachnoid tissue, and by three incomplete septa, a posterior and two lateral, which not only attach the two membranes to each other, but at the same time divide the subarachnoid space into compartments. The *posterior septum* (*subarachnoid septum*) is placed opposite the posterior median fissure of the cord, and is less marked in the cervical region. It carries blood-vessels to the cord. The *two lateral septa* are formed by the ligamenta denticulata which extend laterally, one from each side of the cord.

The pia mater.—The spinal pia mater is a vascular membrane, thicker and more dense than that of the brain. It is closely adherent to the cord, and sends vertical partitions, or septa, into the anterior and posterior median fissures. Along the anterior median line of the cord the pia is thickened into a glistening band, the *linea splendens*, which extends the entire length of the cord, and ends by merging with the filum terminale. The pia mater is supported at the sides by two lateral bands, the *ligamenta denticulata*, fibrous bands attached to the median lateral aspect of the pia from the level of the foramen magnum to the

level of the first lumbar vertebra, midway between the anterior and posterior nerve roots. From this attachment each ligament extends laterally, and is attached to the dura mater by a number of denticulations (twenty to twenty-two), which pass lateralward in the interval between the anterior and posterior roots of the spinal nerves. These processes push the arachnoid before them. It will be seen from this arrangement that the ligamenta denticulata divide the subarachnoid space into two compartments, the anterior of which contains the anterior roots and the posterior, the posterior roots of the spinal nerves. The posterior compartment is again divided by a third, or posterior, septum, already mentioned. The ligamenta denticulata swing the cord in the center of the dural sac. From the conus medullaris the pia mater is continued downward as the fibrous portion of the slender thread, the *filum terminale*, as far as the base of the coccyx, to the periosteum of which it is attached. The filum terminale contains very little nervous matter, and can be distinguished from the nerves of the cauda equina, which surround it, by its glistening white appearance.

The cord segments are arbitrary divisions without anatomic constrictions that can be identified upon the surface. Each segment gives origin to an anterior, and receives a posterior nerve root. The portion of the spinal cord with which the root fibers of a spinal nerve are connected constitutes its spinal segment, the limits of which lie in the intervals separating the extreme fibers of the nerve and those of the adjacent nerves. These nerves, usually comprising thirty-one pairs, are classified as eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal. **The anterior and posterior roots** of the spinal nerves emerge from the anterolateral and posterolateral aspects of the cord and form a double row on each side. The *anterior roots* arise from the anterior horns of the gray matter, and are composed of efferent motor, and white rami sympathetic fibers. The latter have their cells of origin in the lateral portions of the gray matter of the cord, and convey motor impulses to the unstriped muscle of the vessels and the viscera, and secretory fibers to the glands of the splanchnic area; they also convey motor impulses to the heart. The function of plastic muscle tone has recently also been attributed to these fibers. Not all of the spinal nerves, however, give off white rami, these strands of communication forming a thoraco-lumbar group from the first or second thoracic to the second or third lumbar nerves, inclusive, and a sacral group derived from the second and third, or third and fourth sacral nerves. The cervical nerves do not give off white rami.

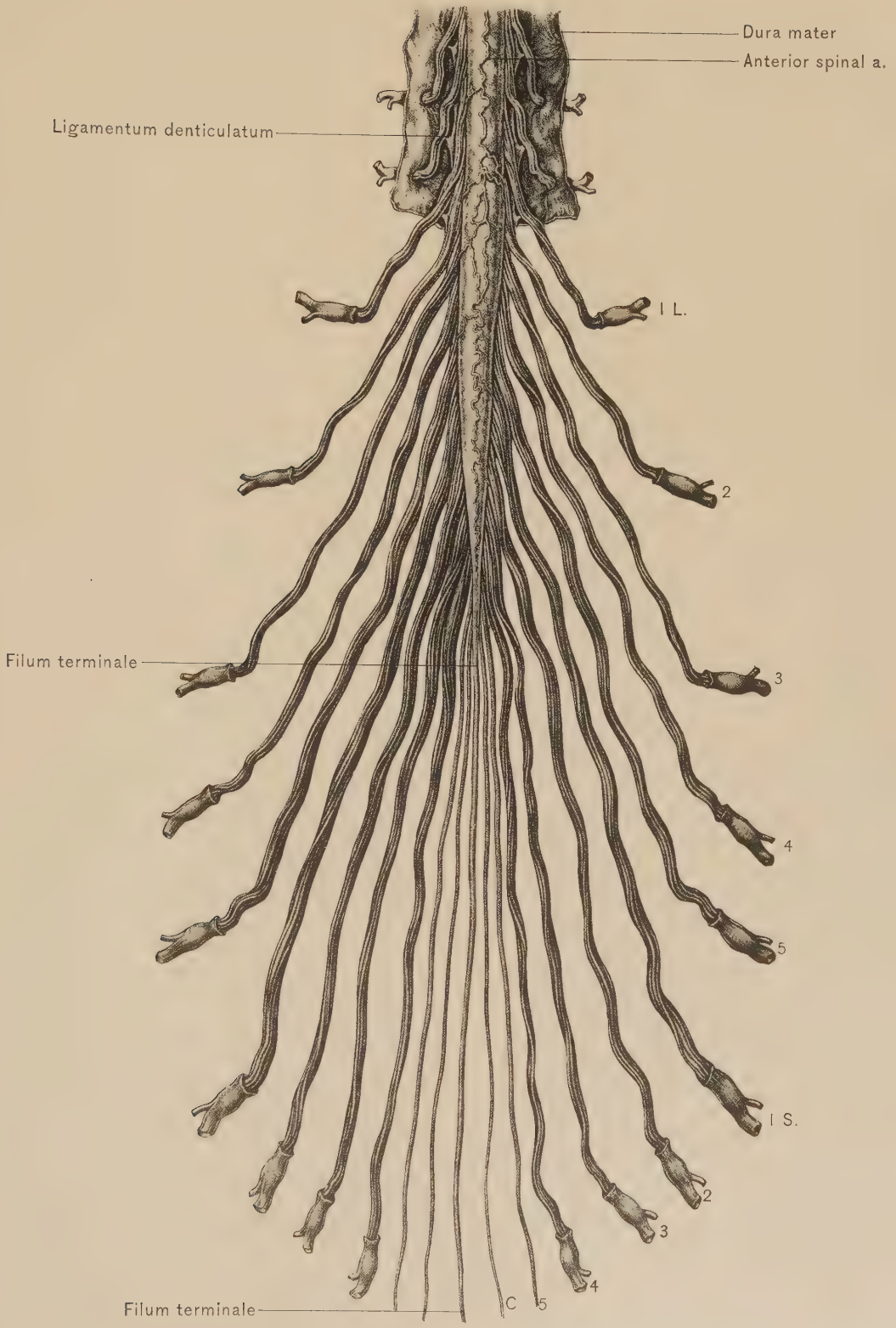
The fibers of the anterior roots emerge from the surface of the spinal cord over a curved field, the *ventral root area*, where they form five to ten filaments, *fila radicularia*, which converge into two main bundles before consolidating into anterior roots.

The *posterior roots* contain sensory fibers which enter the posterior horns of the dorsal aspect of the cord. The posterior roots are larger than the anterior roots and are composed of centripetal, or afferent, fibers whose cells of origin lie in the dorsal ganglia. The dorsal roots carry sympathetic fibers on their way to the cord from the adjacent sympathetic ganglia. The dorsal roots enter in a single compact bundle, pass through the dura mater, and then break up into a series of thread-like bundles which enter the cord in a direct linear series along the posterolateral sulcus.

These nerve roots pass along for varying distances within the dural sheath of the cord. This intradural portion of their course, known as the *intrathecal course* of the nerves, is shorter above and longer below, since the upper spinal nerves pass almost transversely lateralward, and the lower ones take a gradually increasing oblique course until the lowest ones run almost vertically downward. Since the cord terminates opposite the second lumbar vertebra, the lumbar and sacral nerves and the coccygeal nerve have a longer intrathecal course than those above. If the lumbar and sacral nerves are cut out with the cord, a condition similar in appearance to the under surface of a horse's tail will be seen, hence the designation *cauda equina* is given to these bundles of nerve roots (Plate CCXXVIII). Since the spinal cord is shorter than the spinal canal, and since the nerves emerge from the whole length of this canal, each succeeding nerve, growing longer in its intrathecal course, is held to the cord by its arachnoid investment until opposite its foramen of exit, where, like the first spinal nerve, it also passes horizontally lateralward. The nerves of the cauda equina, however, pass down the canal parallel to one another and enter the intervertebral foramina a little obliquely. The anterior and posterior roots unite within the intervertebral foramen to form a single nerve. A short distance above the point of junction, each posterior root presents a fusiform swelling, known as a *spinal ganglion*, which contains the trophic center for the sensory fibers of the spinal nerve.

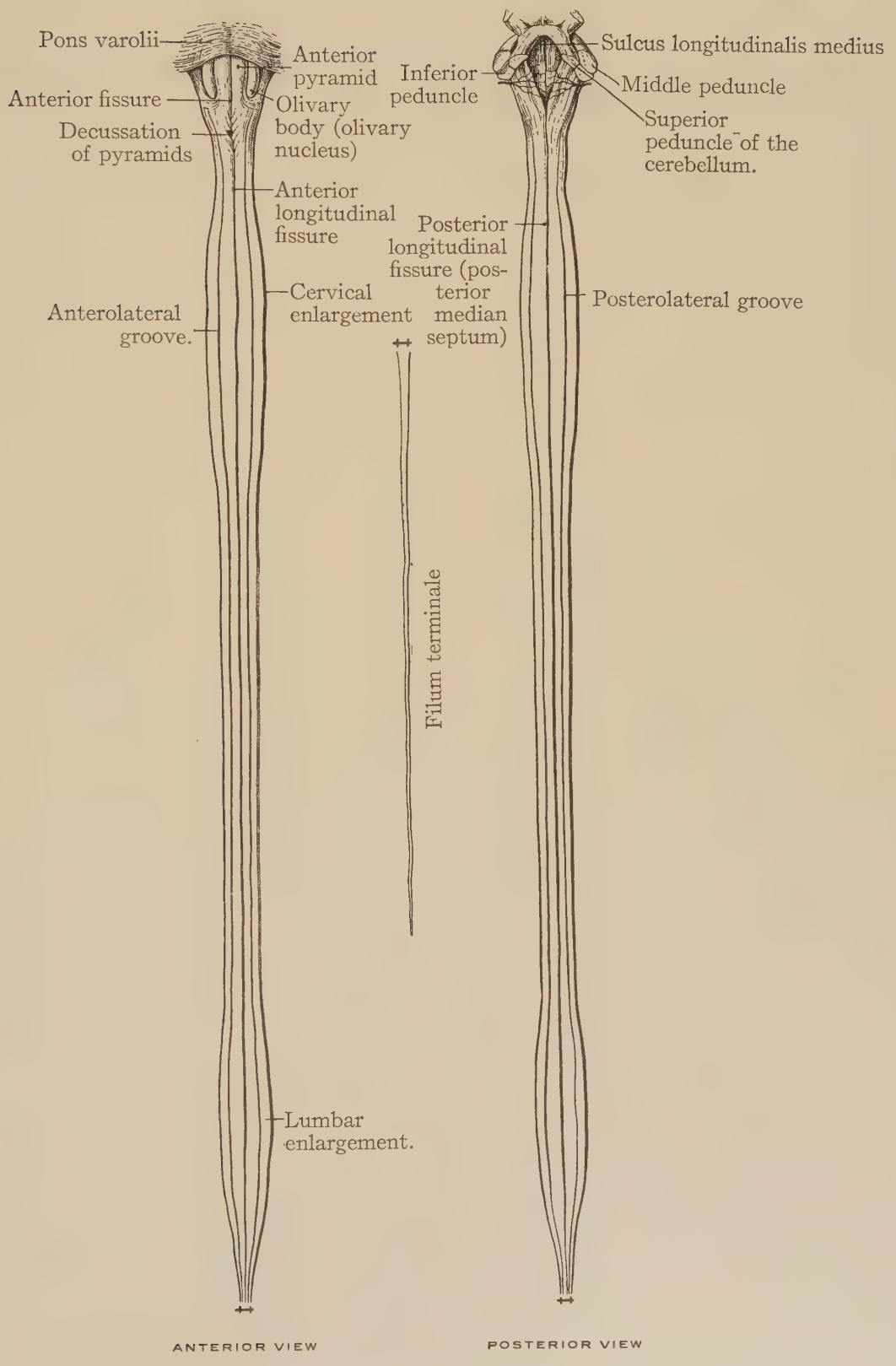
The surface of the spinal cord, especially in cross section, will be seen to be divided into a symmetric right and left half by an anterior cleft and a posterior septum, the **fissures of the spinal cord.** (Plate CCXXIX.) The **anterior median fissure** penetrates only to about one-third of the anteroposterior diameter of the cord. It extends the entire length of the cord, and is the continuation of the corresponding fissure of the medulla oblongata, at the lower part of which it is considerably interrupted by the decussation of the pyramids. The pia mater dips into it as a double fold. The **posterior median fissure** or septum is not an open, true fissure, but a narrow cleft, over which the pia mater passes, but into which it sends no prolongation. It is continuous with the corresponding fissure of the medulla oblongata, and penetrates to one-half the diameter of the cord, as far

PLATE CCXXVIII.



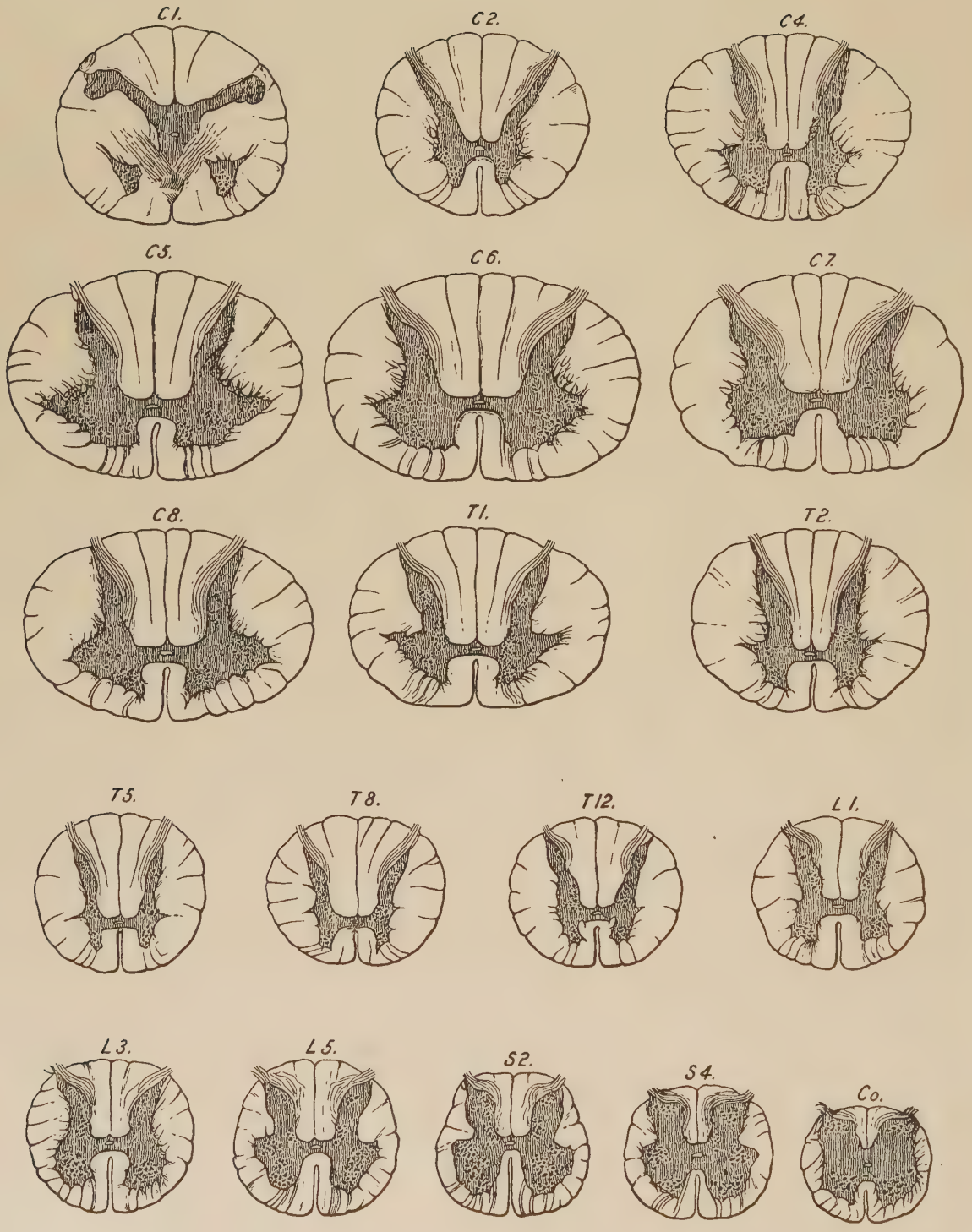
CAUDA EQUINA.

PLATE CCXXIX.



FISSURES OF THE SPINAL CORD.

PLATE CCXXX.



SECTIONS OF SPINAL CORD. W. R. GOWERS.

as the gray commissure. With the anterior median fissure it divides the cord into two symmetrical halves.

Each half of the spinal cord is again divided by an **anterolateral** and a **posterolateral fissure,** or **sulcus,** at the lines of emergence of the anterior and posterior roots of the spinal nerves. The anterolateral fissure is more imaginary than real, since the fibers of the anterior roots of the nerves leave the cord in from three to eight thin bundles, not arranged in a single plane, but overlying one another in a crescentic arrangement. The posterolateral fissure, however, is well marked, the fibers of the posterior roots of the nerves entering it in a single row of bundles. It is deepest in the cervical region, and is continuous with the dorsolateral fissure of the medulla.

In the spinal cord the arrangement of white and gray matter is the reverse of that in the brain, its white matter being upon the outside and the gray matter inside, although the gray matter comes to the surface at the posterior median and posterolateral fissures.

The **Macroscopic Structure of the Spinal Cord** (Plate CCXXX) in a transverse section is very simple. If cut across, it is found to consist of white matter enveloping an H-shaped central mass of gray matter. The arms of the H are in the form of crescents whose convexities are adjacent and united by a band of gray matter, called the **gray commissure,** a misnomer, however, as the commissure is chiefly composed of decussating, and not commissural fibers. The anterior ends of these crescents are expanded and the posterior ones tapering, so that the crescents are sometines described as being comma-shaped. The portion of the crescent in front of the commissure is the anterior horn, or cornu (*anterior gray column*), and that behind it, the posterior horn, or cornu (*posterior gray column*). The anterior horn (*anterior gray column*) is short and thick, and is separated from the adjacent surface of the cord by a layer of white matter through which the anterior root fibers run to their point of exit. The anterior horns (*anterior gray columns*) do not reach the surface, but send out numerous fibers to compose the anterior roots of the spinal nerves. The posterior horn (*posterior gray column*) is long and tapering, receiving the posterior roots of the spinal nerves, and closely approaching the surface of the cord. The **substantia gelatinosa Rolandi** is a translucent mass of modified gray matter which caps the tip (*caput cornu*) of the posterior horn, and is lighter and less opaque than the caput cornu which it covers. In the centre of the gray matter is the **central canal,** visible to the naked eye as a very small spot. It is lined with epithelium, which has its origin from the embryonic cells lining the neural canal, and is continuous above with the fourth ventricle of the brain. This canal is the remnant of the original neural canal of the embyro from the walls of which the spinal cord is

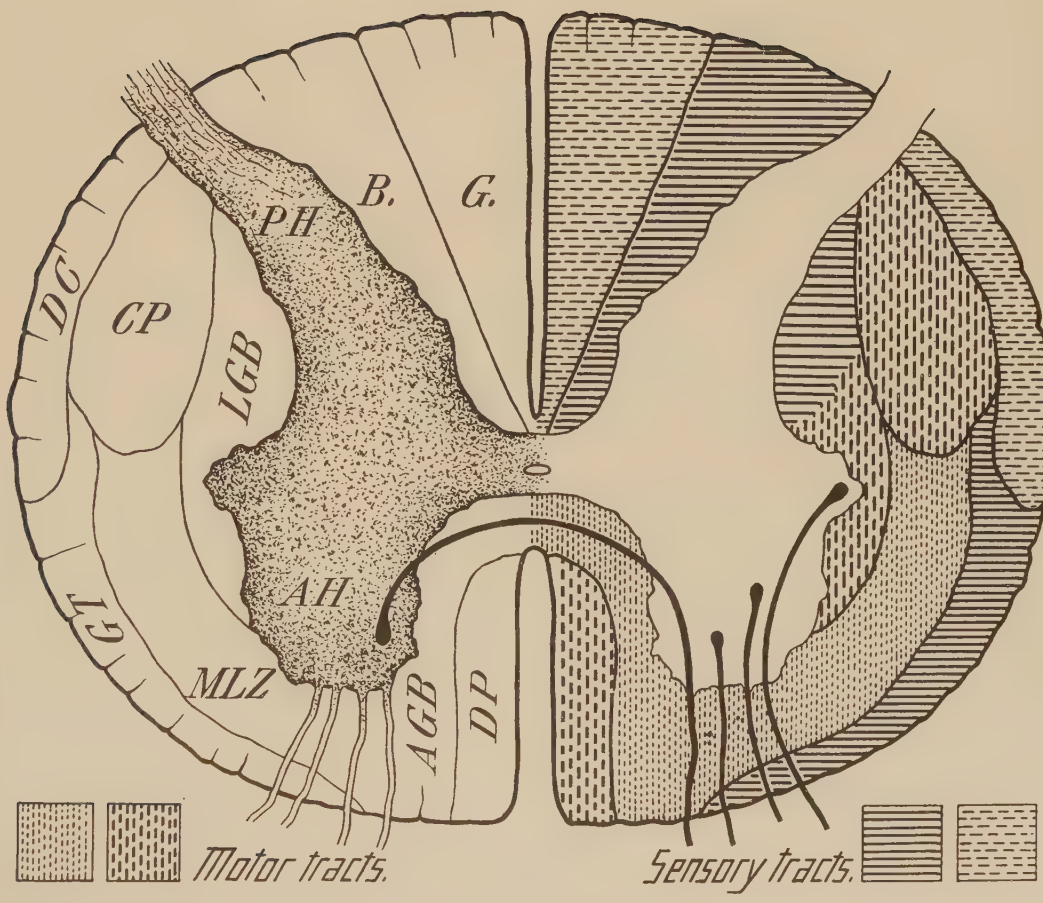
formed. In front of the gray commissure, between it and the bottom of the anterior median fissure, is a layer of white substance called the **anterior white commissure.** The entire gray matter forms a continuous column with irregular outlines, the latter depending on the disposition and variation of gray matter at different levels of the spinal cord. The absolute amount of gray matter is greater within the cervical and the lumbar enlargements, where it is in direct relation with the large nerves that supply the limbs. The absolute amount of white matter also increases in these enlargements, coincidentally with the greater amount of gray substance. In the lower third of the lumbar region, the amount of gray and of white matter is about equal, while below this level the gray substance predominates. In the remaining regions, however, the white matter is in excess of the gray—four to five times in the greater part of the thoracic cord, and two to three times in the cervical cord.

It is through embryologic and pathologic studies that the structure of the white matter is known to us. These studies show that the medullated nerve fibers in the white matter of the spinal cord have a definite arrangement, each half of the spinal cord being divided by the posterolateral fissure into an anterolateral and a posterior column, or tract (Plate CCXXXI).

The **Anterolateral Column** contains the direct pyramidal (*anterior cerebro-spinal fasciculus*), the crossed pyramidal (*lateral cerebro-spinal fasciculus*), the prepyramidal (*rubro-spinal fasciculus*), and direct cerebellar tract (*posterior spino-cerebellar fasciculus*), Gower's tract (*anterior spino-cerebellar fasciculus*), and the anterolateral ground bundles (*fasciculi proprius anterior and proprius lateralis*).

The **direct pyramidal tract** (**anterior cerebro-spinal fasciculus**), also known as the column of Türck, is a *descending*, or *motor*, tract, lying near the anterior median fissure. It is the continuation of the anterior pyramid of the medulla, and contains those fibers which do not decussate in the medulla, but pass into the cord on the same side. The tract tapers as it passes downward to terminate at about the middle of the thoracic region. After entering the tract the fibers cross at various levels by way of the white commissure to the opposite anterior horn, to end around the anterior root cells.

The **crossed, or lateral, pyramidal tract** (**lateral cerebro-spinal fasciculus**) contains the greater number of the decussating fibers of the anterior pyramid of the medulla. They pass downward in the posterior portion of the lateral column anterior to Lissauer's zone (*posterolateral fasciculus*) as a compact bundle, which, in cross section, is seen to occupy a triangular area between the posterior horn and the lateral surface of the cord, but is separated from both by fibers belonging to other systems. The tract thus consists of *descending* fibers, and



G. Column of Goll (*Fasciculus gracilis*). *B.* Column of Burdach (*Fasciculus cuneatus*). *P.H.* Posterior Horn. *A.H.* Anterior Horn. *D.C.* Direct Cerebellar Tract (*Posterior spino-cerebellar fasciculus*). *C.P.* Crossed Pyramidal Tract (*Lateral cerebrospinal fasciculus*). *L.G.B.* Lateral Ground Bundle (*Fasciculus proprius lateralis*). *G.T.* Gowers' Tract (*Antero-lateral superficial fasciculus*). *M.L.Z.* Mixed Lateral Zone. *A.G.B.* Anterior Ground Bundle (*Fasciculus proprius anterior*). *D.P.* Direct Pyramidal Tract (*Anterior cerebro-spinal Fasciculus*).

can be traced down as far as the fourth sacral segment, becoming gradually smaller and approaching the surface of the cord as it descends. Some fibers of this tract are scattered in other parts of the lateral column.

The **prepyramidal tract** (**rubro-spinal fasciculus**), known also as Monakow's bundle, lies immediately in front of the pyramidal tract. It is a crossed motor tract, consisting of *descending* fibers which originate in the red nucleus of the tegmentum of the mid-brain and which terminate either directly or indirectly in relation with the motor cells of the anterior column. This tract is important in transmitting coördinating impulses.

The **direct cerebellar tract of Flechsig** (**posterior spino-cerebellar fasciculus**) lies between the lateral pyramidal tract and the lateral surface of the cord, extending forward almost half way to the anterior root. It begins at the level of about the second or third lumbar nerve, ascends to form part of the restiform body, or inferior cerebellar peduncle of the medulla, increasing in size as it ascends. Its fibers thus are *ascending* fibers. The direct cerebellar tract originates in the cells of Clark's column, a group of nerve cells in the spinal column, through which its fibers are in direct communication with the posterior nerve roots on the same side. It establishes direct communication between the spinal cord and the centers of coördination in the brain.

Gower's tract (**anterior spino-cerebellar fasciculus**), is a band, composed of *ascending* fibers, on the surface of the cord in front of the direct cerebellar tract. It conveys sensory impulses from the muscles and skin to the cerebellum to assist it in coördinating more precise movements. Intermingled with this tract are a number of less distinct fibers—the *spino-tectal* bundle (*spino-tectal fasciculus*) and *spino-thalmic* bundle (*spino-thalmic fasciculus*)—which, instead of passing to the cerebellum, are continued up the pons and midbrain, to end partly in the corpora quadrigemina and partly in the thalamus. Pain, heat, and cold are carried by the former and are of considerable importance as they receive their fibers from the *opposite* posterior nerve roots, crossing within one or two segments after entering the posterior horn. Cutting of these fibers is known as cordotomy, and is usually performed in the upper thoracic region. The operation is undertaken to relieve intractable pain in the lower half of the body, and section of this tract produces loss of pain and temperature sense on the opposite side of the body.

The **anterolateral ground bundle** (**fasciculi proprius anterior and proprius lateralis**) comprises the remainder of the anterolateral tract. Its composition is rather complex, consisting of long and short, *ascending* and *descending* fibers, which principally form association paths connecting the various segments of the cord with each other.

It is divided into the anterior ground bundle and the lateral ground bundle. The *anterior ground bundle* (*fasciculus proprius anterior*) is separated from the remainder of the anterolateral ground bundle by the anterior roots of the spinal nerves and the cornu. It contains ascending and descending fibers which connect the cells of the anterior cornu and are important in conveying unilateral reflex impulses. The *lateral ground bundle* (*fasciculus proprius lateralis*) is bounded anteriorly by the anterior ground bundle and posteriorly by the crossed pyramidal tract.

The **posterior column** of the white matter of the cord is divided into two tracts: one internal, or column of Goll (*fasciculus gracilis*), and the other external, or column of Burdach (*fasciculus cuneatus*), separated by a paramedian septum, and on the surface of the cord by a furrow, or sulcus.

The **column of Goll** (**fasciculus gracilis**) is in relation with the posterior median fissure. It contains *ascending* fibers which are derived from the posterior roots of the nerves of the lower extremities and the thorax, and the others which connect the cells of the posterior cornu.

The **column of Burdach** (**fasciculus cuneatus**) lies between the column of Goll and the posterior cornu. It also contains *ascending* fibers which are derived from the posterior roots of the upper spinal nerves, and other fibers associated with the cells of the posterior cornu. A cross section of the lumbar cord, therefore, shows only the column of Goll, whereas a section taken in the cervical region shows both the column of Goll and of Burdach. The fibers of these two tracts have their upper ends about the cells of Goll (*nucleus gracilis*) and the nucleus of Burdach (*nucleus cuneatus*), whence they are continued by a second set of fibers, which, after decussating in the medulla, pass by way of the median lemniscus to the optic thalamus on the same side. The fibers of these tracts are devoted to light touch and tactile discrimination between two points of the compass, to vibratory sensation and sense of passive movement, as well as the muscular sense of position, and are therefore of considerable importance in the pathology of tabes dorsalis, a disease of the posterior columns and the posterior nerve roots, in which there is loss of vibratory sensation, and sense of muscular position, with consequent incoördination of muscular movements.

Another tract is a small zone, **the boundary zone of Lissauer** (**posterolateral fasciculus**), composed of some of the lateral fibers of the posterior roots of the spinal nerves. These fibers pass upward in the medulla close to the substantia gelatinosa Rolandi which is a prolongation of the fifth cranial nerve nucleus downward into the cord.

The rest of the posterior column, the *fasciculus proprius posterior*, consists of fibers of varying length, most of which are association fibers between different segments of the cord.

The **Arteries of the Spinal Cord** are the anterior spinal artery and the posterior and lateral spinal arteries which form upon the cord an anterior median and four posterolateral arteries.

The **anterior spinal artery** is a small branch which arises from the vertebral artery near its termination. It joins its fellow of the opposite side in front of the medulla oblongata, and forms a single anterior median vessel which descends in front of the cord to its termination and for some distance on the filum terminale. It is joined on either side by branches from the lateral spinal arteries. This median vessel lies beneath the pia mater in the anterior median fissure, and supplies the gray matter of the cord.

The **two posterior spinal arteries** are derived from the vertebral artery at the sides of the medulla; each artery passes to the side of the cord and divides into an anterior and a posterior branch, the one running in front of the posterior roots of the spinal nerves and the other behind them. These arteries continue down the posterolateral aspect of the cord to its termination where they form the *coronal circulation*, supplying the white matter of the cord. They are joined by the lateral spinal arteries, and supply the adjacent cord, membranes, and cauda equina.

The **lateral spinal arteries,** so called because they pass along the sides of the cord, have various origins. In the cervical region they are branches of the vertebral, ascending cervical, and deep cervical arteries; in the thoracic region, of the dorsal branches of the intercostal, and in the lumbar region, of the lumbar arteries. They enter the spinal canal through the intervertebral foramina and divide into two branches, one of which goes to the back of the bodies of the vertebræ and the other reaches the cord upon the posterior root of a spinal nerve. Some of the latter branches join the anterior median artery, while the others either terminate in the nerve root or join the posterolateral arteries of the cord. They supply the cord, its membranes, and the vertebræ.

The **Veins of the Spinal Canal and Spinal Cord** are the dorsi-spinal, the meningo-rachidian, the venæ basis vertebræ, and the veins of the cord itself. All the veins of the spinal canal and spinal cord are devoid of valves (Plate CCXXVI).

The **meningo-rachidian veins** have been described at p. 398.

The **veins of the spinal cord** (*medulli-spinal vein*) form a plexus over the surface of the cord within the pia mater, and emerge chiefly from the anterior and posterior median fissures. Branches from the plexus pass lateralward upon the nerve roots and communicate with the meningo-rachidian veins which, in the upper part of the spinal canal, empty into the vertebral and the inferior cerebellar veins or into the inferior petrosal sinuses, and in the lower part of the canal, into the intercostal and lumbar veins.

The **Motor, Sensory, and Reflex Areas** of the body are governed by the spinal cord at different levels (Plate CCXXXII). Without going into details as to the structure or function of the spinal cord, it may be well to say a few words upon the subject. While most of the motor fibers cross at the decussation of the pyramids in the medulla, the sensory fibers cross in the cord throughout its entire length. This difference in the motor and sensory decussation is only anatomic, for, from the functional standpoint, they follow the same principle in that they cross practically upon their entrance into the cord: the motor fibers, with the exception of those of the direct pyramidal tract, entering above *en masse*, soon decussate in a body; the sensory fibers, entering at different levels, cross over soon after their entrance, thus decussating separately all along the cord.

Reflex Action is the term used to indicate the centripetal impulse along a sensory nerve to the nerve center (gray matter) and the resulting centrifugal (return, reflected) impulse along a motor nerve, the complete path of this impulse being known as a *reflex arc.*

Each portion of the spinal cord from which a pair of spinal nerves arises is termed a segment, though, of course, there is no anatomic separation of the cord into these segments.

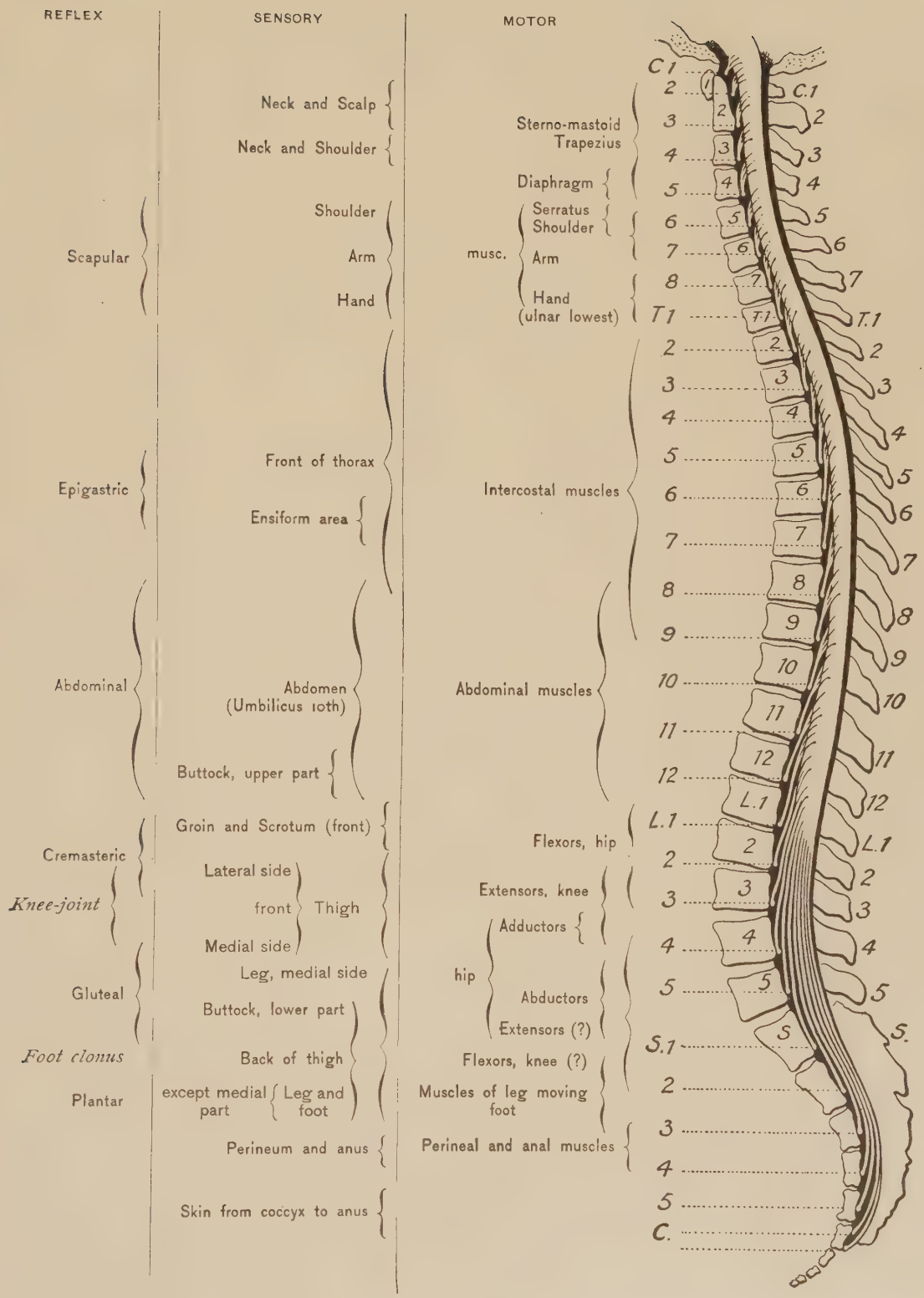
Diseases of the spinal cord may be divided into two large groups: *diffuse and local diseases of the spinal cord* and those involving certain *systems* and *tracts*. The former include conditions such as, myelitis, compression, tumors, syringomyelia, hematorrhachis, disseminated sclerosis, herpes zoster and Landry's acute ascending paralysis. Under system diseases are spastic paraplegia, ataxic paraplegia, and the myelopathic muscular atrophies.

The signs of *lesions of the cord* depend upon the sensory and motor disturbances produced, and these of necessity vary with the site of the lesion. The correct interpretation of the neurological findings will give an accurate localization of the lesion or indicate the type of disease involving definite systems or areas of the spinal cord.

It is necessary to bear in mind the functions of the various tracts involved in order to interpret correctly the symptoms and physical findings in cord lesions.

The **Motor System** is composed of two separate sets of fibers, the *upper motor neurones* whose cells lie in the cortex of the brain in the precentral convolution, giving rise to the fibers of the pyramidal tracts (*lateral cerebro-spinal fasciculi*) which descend to end about the anterior horn cells of the cord on the opposite side, and the *lower motor neurones* whose cells lie in the anterior horns, and send their fibers from this point to end in the muscle fibers supplied by the nerves of that segmental distribution.

PLATE CCXXXII.



APPROXIMATE RELATION TO THE SPINAL NERVES OF THE VARIOUS MOTOR, SENSORY, AND REFLEX FUNCTIONS OF THE SPINAL CORD (GOWERS).

Involvement or destruction of the upper motor neurone system gives rise not only to paralysis below the level of the lesion, but also to an increase of reflexes and a spasticity of the muscle groups. The reflex arcs, being freed from the inhibitory influence of the cortex, allow unrestricted response of the muscles when properly stimulated, hence the exaggeration of the reflexes. Lower motor neurone involvement gives rise to just the reverse picture, as there is a flaccid type of paralysis, and a complete loss of the reflexes because the arc has been destroyed. There is atrophy instead of spasticity of the muscles involved. It is clear, then, that with a lesion of the spinal cord involving the motor system there are paralysis, spasticity, increase of reflexes, ankle clonus, and a positive Babinski sign below the level of the lesion on the same side. There are a flaccid paralysis, loss of reflexes, and atrophy at the level of the lesion, because of the anterior horn cell involvement or anterior root destruction.

An accurate check of this level must be made by testing the *sensory fibers* to determine the level and extent of the lesion involving this system of pathways. This is done by appropriate tests for the three main groups of fibers in the spinal cord.

Tactile and Vibratory Impulses.—The primary sensory neurones at once enter the *posterior columns*, and ascend in these almost the entire length of the cord. At various levels the fibers give off collaterals which enter the posterior horns and end around the cells. The fibers from these cells—secondary sensory neurones—immediately cross the cord in the posterior commissure, and pass to the anterior ground bundle (*fasciculus proprius anterior*) of the opposite side, forming an ascending tract between the direct pyramidal (*lateral cerebro-spinal fasciculus*) and the anterior horn. Owing to this alternative tract and numerous collaterals, light touch sensation is rarely completely abolished in lesions of the cord.

Impusles of Pain and Temperature.—The primary sensory neurones enter the *posterior horns*, and shortly end about cells. The secondary sensory neurones from these cross the cord at once in the posterior commissure close to the central canal, and ascend in Gower's anterolateral ascending tract (*anterior spino-cerebellar fasciculus*) (of the opposite side). Syringomyelia injures these fibers while *crossing the cord;* being arranged here in the order of heat, cold, and pain from before backward, heat may be affected more than cold and cold more than pain.

Sense of Position and Passive Movement.—The primary sensory neurones at once enter the *posterior columns* and ascend on the same side to Burdach's (*cuneate*) and Goll's (*gracile*) nuclei. Collaterals of the fibers end around cells in Clark's column, whence the secondary sensory neurones pass lateralward through the lateral pyramidal tract (*lateral cerebro-spinal fasciculus*) to the direct cere-

bellar tract (*anterior spino-cerebellar fasciculus*) and ascend in this. This group of impulses is affected in tabes dorsalis.

Lesions of the cord, if unilateral, it is evident, will cause a *dissociation of sensation* because of the divergent pathways, so that certain forms of sensation will be involved on the side of the lesion, and others will show involvement of the opposite side because of the crossed tracts, especially those of pain and temperature.

In the **Brown-Sequard syndrome,** which is present in unilateral lesions of the cord, there are found on the **same side as the lesion:** in the affected segment of the cord (1) a zone of anesthesia, with an area of hyperesthesia above, due in the first case, to destruction of the posterior root entering at that segment and, in the latter case, to the irritation of the root above; (2) atrophic flaccid paralysis, due to the involvement of the anterior horn cells or the anterior root at the level of the lesion; below the affected segment we find, on the side of the lesion (1), paralysis of the upper motor neurone type; (2) loss of the sense of position, localization of touch, and passive movements.

On the opposite side of the lesion there is loss of the sensation of pain and temperature, as well as deep pressure sense. Touch will be slightly affected. There will be no motor changes.

Tumors of the cord are usually associated with severe root pains at the level of or below the lesion, and are characterized by a slowly increasing spastic form of paralysis with the development of the **Brown-Sequard syndrome,** noted above. Occasionally, if the tumor arises on the anterior aspect of the cord, pain is not a marked feature, paralysis developing first.

Protection to the spinal cord is provided by: the free mobility of the spinal column as a whole; the slight amount of movement between any two vertebræ; the elastic intervertebral discs which break any force or shock applied to the spinal column; the comparatively large size of the spinal canal in the cervical and lumbar regions, where mobility is most marked; the curves of the spinal column which lessen shock and force; suspension of the cord in the spinal canal by the ligamenta denticulata; the spinal dura mater which is so tough that the cord may be ruptured without laceration of the dura, and by the cerebro-spinal fluid.

Blood Supply.—The blood supply of the spinal column and its articulations is derived from: the vertebral, occipital, ascending pharyngeal, ascending cervical, intercostal, lumbar, ilio-lumbar, middle sacral, and lateral sacral arteries.

Nerve Supply.—From the spinal nerves.

Fractures of the Spinal Column are usually produced by indirect violence, such as overflexion or overextension, as when a person falls upon the head or the

buttocks, or is stooping and a heavy weight falls upon the shoulders causing rupture of one of the supraspinal ligaments and fracture of the posterior arches of one or two of the vertebræ near the point of rupture. Usually the fragments so completely crush the cord that operation to remove or elevate them does not improve the condition.

Fractures and dislocations of the vertebræ fall in two classes: incomplete and complete.

Incomplete fractures or *fracture dislocations* are those where the continuity of the column is not destroyed; fracture of the transverse processes, spinous processes or the laminæ may occur and occasionally with displacement of these structures. They are of importance because of a possible delayed involvement of the cord and because they frequently produce pain sufficient to incapacitate the individual. They should be carefully looked for in all cases of chronic back-strain.

Complete fractures or *fracture-dislocations* are most common where the more mobile portions of the column join the fixed thoracic group, such as, the lower cervical and upper dorsal regions and the lower dorsal and first lumbar area. Here sudden acute flexion may take place with the production of a fracture-dislocation. Dislocation occurs less frequently than fracture and most often affects the fourth to seventh cervical vertebræ. The deformity produced is a forward displacement of the upper end of the column due to the downward and backward slope of the articular facets of the cervical vertebræ. Luxation between the atlas and axis (*epistropheus*) is rare, but it may occur by rupture of the transverse ligament, fracture of the odontoid process (*dens*), or slipping of the process under the ligament. Bilateral luxation is rare without an associated fracture. It is produced by anterior flexion. Fracture and dislocation are often associated, in fact, dislocation without fracture is rare, although fracture may take place alone. The deformity can usually be recognized at the site of the lesion; there is also pain and rigidity of the spine. In severe trauma the vertebral column is usually displaced forward so that the injury to the spinal cord is profound. The effects of such injury depend upon the segment involved.

Injuries to the Spinal Cord are usually due to direct trauma sustained in a fracture or dislocation, or both, of the vertebral column, although occasionally indirect violence may produce an hematomyelia and diffuse myelitis within the cord without demonstrable fracture or involvement of the vertebral bodies. Certain regions of the cord are more prone to injury than others, due primarily to the frequency of fractures at the juncture of the less mobile thoracic group of vertebræ with the cervical and the lumbar groups. The atlo-axial (*atlo-epistropheal*) joint is occasionally the site of dislocation which may involve the upper

cervical cord and lower medulla. Owing to the enlargement of the cord in the cervical and lumbar regions it more nearly fills the canal, and injuries at these points are apt to be more serious.

At times the injury to the cord itself may be slight and give rise to few symptoms, but in the presence of dislocation or fracture-dislocation, there is almost invariably a *transverse myelitis* with marked symptoms below the level of the lesion. This transverse myelitis may be either of only a few weeks' duration or the changes may be permanent, and no improvement in the condition of the individual can be expected. In severe trauma the affected vertebra is usually displaced forward so that the spinal cord may be lacerated, compressed, crushed, or torn by the upper fragment. Immediate decompression and reduction is indicated to allow every opportunity for relief of pressure on the cord. The recovery of function is extremely doubtful, and when actual destruction of cells and fibers has occurred, function cannot be regained, for *regeneration of nerve structures within the spinal cord never takes place.*

Since injury to the spinal cord often occurs without gross deformity of the vertebral column, or following a dislocation which has spontaneously reduced itself, it is necessary to localize the lesion accurately.

In general, a severe injury to the cord producing a transverse lesion gives rise at first to profound spinal shock with flaccid paralysis of all muscle groups below the level of the lesion, absolute loss of all deep and superficial reflexes, and complete anesthesia for touch, pain, temperature, vibration, and sense of position; loss of bladder and rectal control; also vasomotor paralysis with hyperthermia in the areas below the level of the lesion, meteorism, and, if the lesion is high in the cervical region, respiratory embarrassment. Acute trophic lesions occur very early, and sloughing in the bladder and penis or urethra is not uncommon.

If the patient survives the period of spinal shock, there first ensues a return of the reflexes, followed later by spasticity of the muscle groups below the level of the lesion, ankle clonus, and a positive Babinski; reactions of defense then become established, and the bladder and rectum take on an involuntary reflex control.

In attempting to locate the injured segment, it is important to remember that these segments lie at some distance above the point of exit of the corresponding nerve roots and vertebræ. The first seven cervical nerves emerge above their corresponding vertebræ, while the eighth leaves the canal between the seventh cervical and the first dorsal vertebræ. The dorsal, lumbar, and sacral nerves all emerge below their corresponding vertebræ.

Injuries to the cord above the fifth cervical vertebra are almost invariably fatal, because of the involvement of the phrenic centers in the cord, with resultant

paralysis of the diaphragm. If death is not immediate, pulmonary edema follows in about 36 hours with fatal consequences, the accessory muscles of respiration supplied by the spinal accessory being insufficient to maintain aëration of the lungs.

Injuries to the fifth, sixth, seventh, and eighth segments of the cord produce a quadriplegia, the upper extremities remaining flaccid, with loss of reflexes and atrophy, together with marked increase of reflexes in the lower extremities, with spasticity, clonus, and positive Babinski. Anesthesia below the level of the lesion may be partial or complete. Involvement of the cilio-spinal center may be evident with paralysis of the cervical sympathetics to the eye, producing myosis and enophthalmos. Trophic lesions and gangrenous cystitis are frequent complications and make the immediate prognosis extremely grave.

Injuries to the seventh dorsal segment may cause a rapid pulmonary edema, due to an antidromal pulmonary segment reflex which produces vasodilation and passive congestion. Priapism frequently occurs.

The prognosis in injuries below this level is more favorable for life, but recovery of function will be doubtful if actual damage has occured to the cord itself.

Injuries to the mid-dorsal region, in addition to paralysis and anesthesia of the lower extremities, are associated with paralysis of the abdominal walls, meteorism, and constipation, due to abdominal paralysis. The rectum is not paralysed. The bladder at first shows retention with overflow, but later involuntary reflex micturition is established.

Injuries to the lower dorsal and upper lumbar regions of the cord give rise to immediate, true incontinence, due to involvement of the centers, with paralysis and relaxation of the sphincters. There is a marked tendency to sloughing of the skin and of the bladder.

Injuries to the lumbar and sacral regions of the cord give rise to paralysis of all the leg muscles excepting the psoas, iliacus, quadriceps, extensor femoris, and the adductors; also paralysis of all the perineal and penile muscles, saddle anesthesia with loss of sensation in the distribution of the sciatic nerve in the back of the leg and the foot.

Paralysis of the bladder also takes place with retention, at first, which is followed by atrophy of the sphincter muscle, with true incontinence. The rectal sphincter is likewise paralysed and incontinence of feces results.

JOINTS OF THE HEAD AND NECK

The **Joints of the Skull,** excepting the temporo-maxillary (*mandibular*) articulation and the articulations between the skull and the spinal column, are in the form of sutures which afford immobility and firmness with elasticity.

The **Sutures of the Skull** may be mistaken for fractures, and the Wormian (*sutural*) bones, which are situated in the lines of the sutures, may be mistaken for fragments outlined by fractures.

The **sagittal suture** is situated in the median line of the vault of the cranium, and extends from the bregma to the lambda. The *bregma*, or *sinciput*, is situated at the junction of the coronal and sagittal sutures, and at the point where a line, drawn perpendicular to Reid's base line at the pre-auricular fossa crosses the median line of the cranial vault. The *lambda* is situated at the junction of the sagittal and lambdoid sutures, and about seven centimeters (two and three-quarter-inches) above the external occipital protuberance.

The **coronal suture** extends from the bregma downward and slightly forward toward the junction of the zygoma with the malar (*zygomatic*) bone.

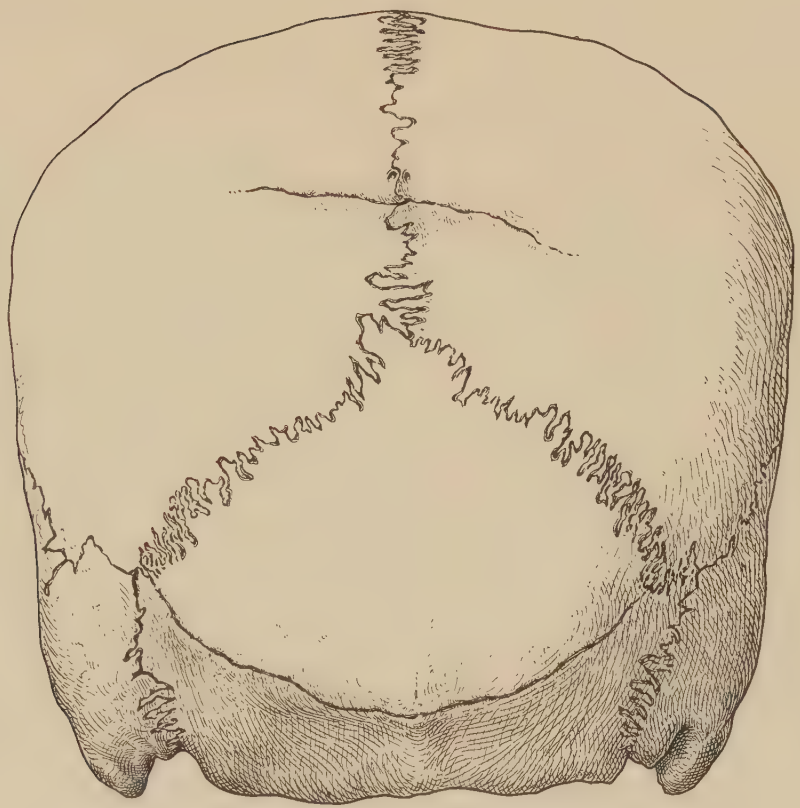
The **lambdoid suture** is situated at about the upper two-thirds of a line drawn from the lambda to the apex of the mastoid process of the temporal bone. Additional sutures, not commonly present, may exist in the vault of the cranium and be mistaken for fractures. These are the **frontal suture,** which extends forward between the halves of the frontal bone in the line of the sagittal suture, the **parietal fissure,** a short suture which crosses the sagittal suture two and one-half centimeters anterior to the lambda, and the **transverse occipital fissure,** which is a suture situated in the occipital bone near the level of the external occipital protuberance (Plate CCXXXIII).

The **Temporo-maxillary** (**Mandibular**) **Articulation** (Plates CCXXXIV; CCXXXV) is the joint situated between the condyle of the inferior maxilla (*mandible*) and the glenoid (*mandibular*) fossa of the temporal bone. It is an arthrodial diarthrosis, or hinge joint, modified to allow gliding movement. The ligaments of the temporo-maxillary (*mandibular*) articulation are the capsular ligament, the external lateral (*temporo-mandibular*) ligament, and the interarticular fibrocartilage which divides the joint into an upper and a lower part. The joint is strengthened by the spheno-mandibular and the stylo-mandibular ligaments, although the latter ligament is not directly associated with the articulation.

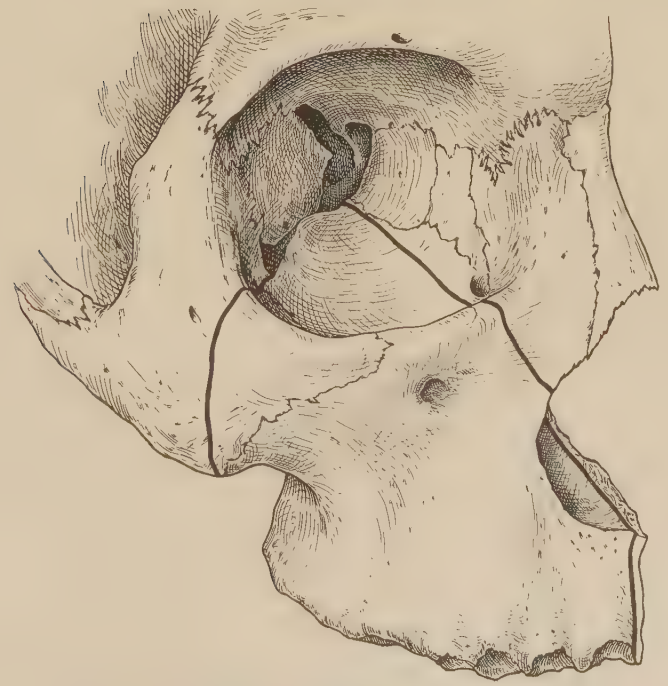
The **capsular ligament** is thin, especially at its anterior and medial portions. It is attached above to the margins of the articular surface formed by the eminentia articularis (*articular tubercle*) and the circumference of the glenoid (*mandibular*) fossa of the temporal bone, and below to the neck of the mandible. It is also attached to the edge of the interarticular fibrocartilage (*articular disc*). Its lateral portion is much stronger than the remainder of the capsule, and is termed the external lateral (*temporo-mandibular*) ligament.

The *external lateral* (*temporo-mandibular*) *ligament* is attached above to the lower margin of the zygoma and the tubercle of the zygoma, its fibers passing

PLATE CCXXXIII.

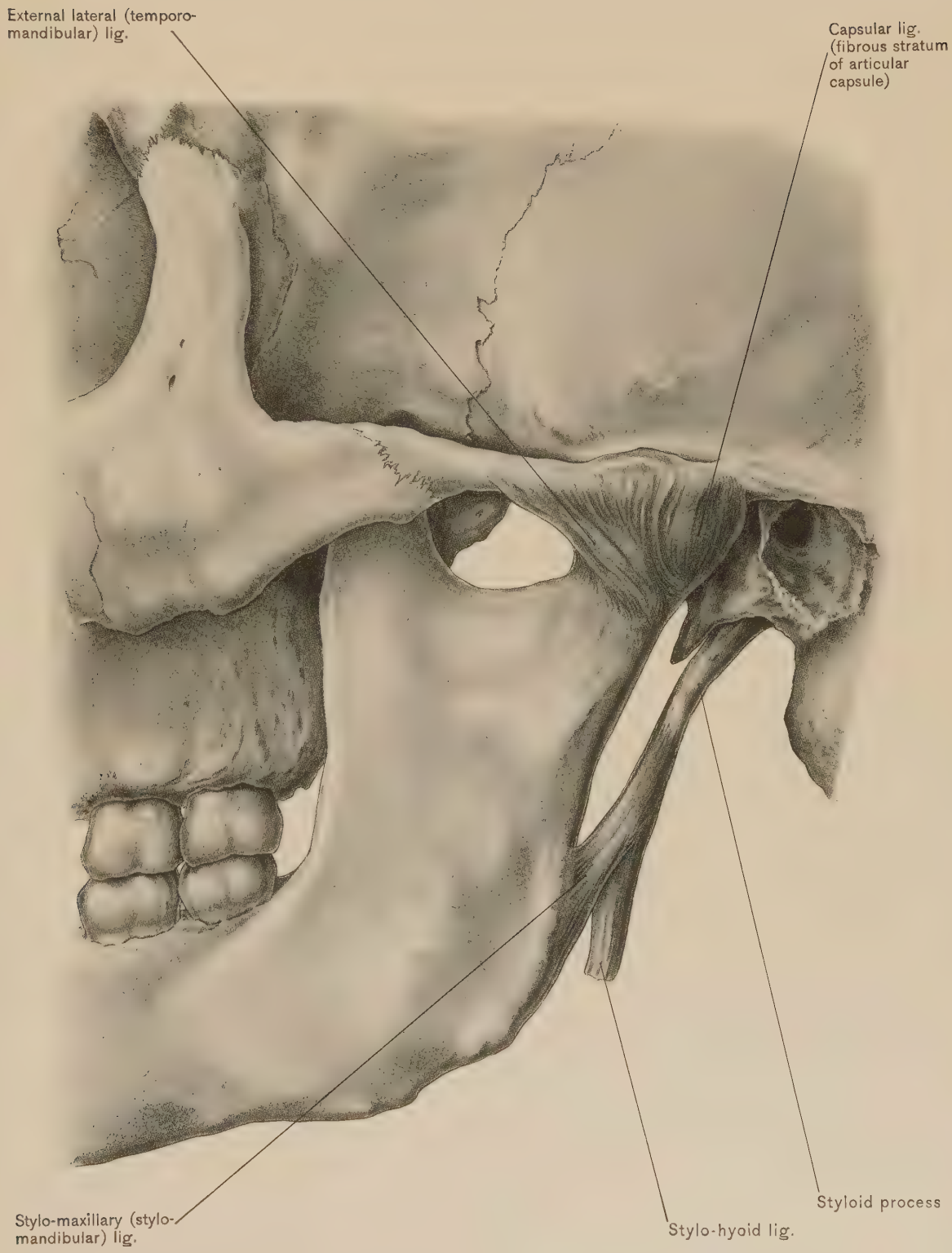


PARIETAL AND TRANSVERSE OCCIPITAL FISSURES.



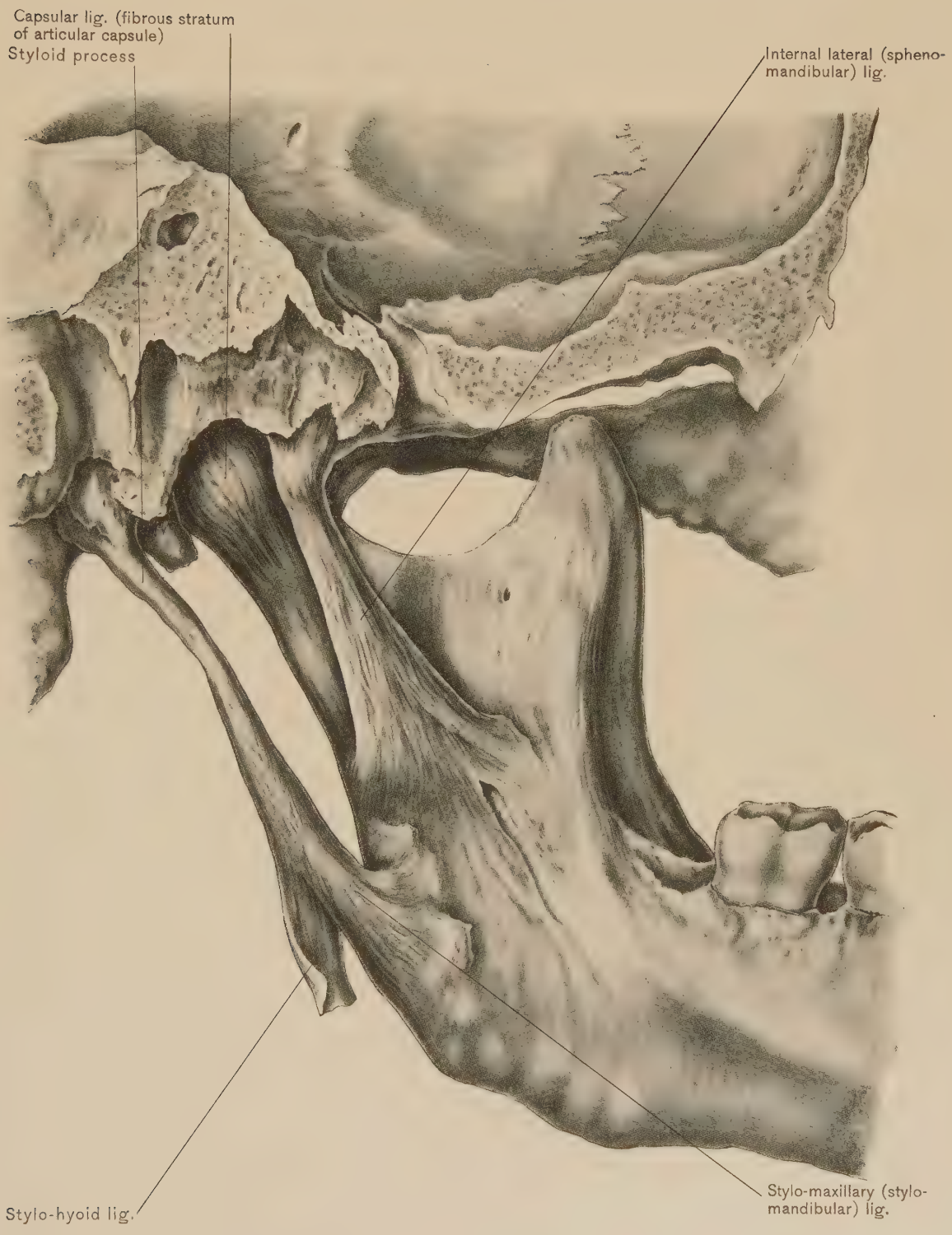
LINES IN WHICH BONE IS DIVIDED IN EXCISION OF MAXILLA

PLATE CCXXXIV.



TEMPORO-MAXILLARY (MANDIBULAR) ARTICULATION—EXTERNAL VIEW.

PLATE CCXXXV.



TEMPORO-MAXILLARY (MANDIBULAR) ARTICULATION—INTERNAL VIEW.

downward and backward to be attached below to the lateral surface and the posterior margin of the neck of the mandible.

The **interarticular fibrocartilage** (**articular disc**) is situated within the capsule between the articular surfaces of the bones entering into the formation of the joint. Through conformation to these surfaces its upper surface is concavo-convex from before backward and convex laterally, and the posterior portion of its under surface is concave, to fit the condyle. It is thin at its center and somewhat thicker posteriorly, where it acts as a buffer and protects the thin bone of the glenoid (*mandibular*) fossa. Its margins are attached to the capsular ligament, thus dividing the joint cavity into two completely separated compartments; some of the fibers of the tendon of the external pterygoid muscle pass between the fibers of the anterior portion of the capsular ligament, to be inserted into the anterior margin of the interarticular fibrocartilage (*articular disc*).

The **synovial membranes** are two in number, the superior synovial membrane being separated from the inferior by the interarticular fibrocartilage (*articular disc*). When the latter is perforated, the two synovial sacs communicate.

The **spheno-mandibular ligament** is attached above to the spine of the greater wing of the sphenoidal bone and adjacent part of the temporal bone, and below to the mandibular lingula, or spine, which is situated on the medial surface of the mandible, below and medial to the inferior dental (*mandibular*) foramen. The spheno-mandibular ligament is separated from the temporo-maxillary (*mandibular*) joint and mandible by the internal maxillary artery and vein, the middle meningeal artery, the external pterygoid muscle, the inferior dental (*inferior alveolar*) vessels, and the inferior dental (*inferior alveolar*) nerve. Its lower extremity is pierced by the mylo-hyoid nerve. It is a weak fibrous structure.

The **stylo-mandibular ligament** is a part of that process of the deep cervical fascia which dips beneath the parotid gland. It extends from the styloid process of the temporal bone to the angle and the posterior margin of the ramus of the mandible, separating the parotid from the submaxillary (*submandibular*) gland.

Blood Supply.—From the temporal, the middle meningeal, and the ascending pharyngeal arteries.

Nerve Supply.—From the auriculo-temporal and masseteric branches of the inferior maxillary (*mandibular*) nerve.

Movements.—Rotation of the condyle around a transverse axis occurs when the mouth is opened or closed, and gliding forward of both the condyle and the interarticular cartilage, when the mouth is wide open. If the mouth is opened too wide, as in yawning, the condyle and interarticular fibrocartilage (*articular*

disc) may be completely or incompletely dislocated forward and locked, either in front of or upon the eminentia articularis (*articular tubercle*). In closing the mouth the cartilage and condyle glide backward, and the condyle rotates on the cartilage in the reverse direction. These movements result in a combination of a hinge movement of the condyle with fore-and-aft gliding movement of the interarticular fibrocartilage (*articular disc*). Gliding movement of the interarticular fibrocartilage (*articular disc*) forward occurs when the mandible is thrust forward. Rotation of the condyle around the vertical axis of the neck of the mandible associated with oblique gliding of the interarticular fibrocartilage (*articular disc*) on the glenoid (*mandibular*) fossa occurs in the oblique movements of the mandible in mastication.

The **Joints of the Neck** are those of the cervical portion of the spinal column, which have been described at p. 395.

Dislocations.—Dislocation of the bones of the vault and base of the skull is almost entirely limited to the young skull. Fractures in the line of the coronal, sagittal, and lambdoid sutures may occur.

Dislocation of the mandible is usually forward and bilateral. *Forward dislocation*, the more frequent type, occurs while the mouth is wide open, as during yawning, manipulations by the dentist, or from blows on the chin. Only a small amount of force is required to carry the condyle from a position just behind, to a point upon, or immediately in front of the summit of the eminentia articularis (*articular tubercle*). The anterior portion of the capsular ligament is torn; the interarticular fibrocartilage (*articular disc*) is usually dislocated with the condyle. It is the contraction of the external pterygoid muscle which carries the condyle over the eminentia articularis (*articular tubercle*) into the zygomatic (*infratemporal*) fossa. The condyle is retained in its abnormal position by the upward traction of the temporal, masseter, and internal pterygoid muscles. *Backward dislocation* of the mandible may follow a blow on the chin, and the condyle may fracture the bony portion of the external auditory meatus or be driven into the cranial cavity.

Excisions.—Excision of the maxilla (Plate CCXXXIII) is usually performed for malignant disease, such as sarcoma or carcinoma of the maxillary sinus, or antrum of Highmore. Generally but one maxilla is removed, although both have been removed in one operation.

In excising the maxilla several anatomic facts are to be remembered. The maxilla is in reality a shell of bone which envelops the maxillary sinus, forms a large part of the floor of the orbit, the roof of the mouth, the lateral wall of the nasal fossa, the anterior wall of the spheno-maxillary (*pterygo-palatine*) fossa and the pterygo-maxillary region (*infratemporal fossa*), and the bony basis of the front

of the face below the infra-orbital ridge. Its strongest portions are the malar (*zygomatic*), alveolar, and palatine processes.

In the operation of excision of the maxillary bone the inferior turbinated bone (*inferior concha*), part of the malar (*zygomatic*) bone, part of the palatine bone, and the maxillary, except the upper part of its nasal process, are removed.

The usual method is to make a median incision, beginning slightly less than one and a half centimeters, (one-half inch) below the medial canthus, and carrying it downward along the groove between the nose and the face, around the ala of the nose, below the base of the nose to the median line, and thence through the median line of the upper lip. This incision divides the skin and superficial fascia, some of the muscles of expression, the angular artery and vein, the lateral nasal artery, the artery of the nasal septum, the superior coronary (*superior labial*) artery, and branches of the infra-orbital and facial nerves.

The second incision is carried from the point at which the first incision was commenced lateralward along the infra-orbital margin to a point over the malar (*zygomatic*) bone. This divides a few insignificant blood-vessels. The tissues of the flap outlined are now quickly reflected lateralward, removing them all down to the bone, not considering the periosteum. In elevating this flap the infra-orbital vessels and nerve are divided.

The fibrocartilaginous lateral portion of the nose is detached from the maxilla, and the base of the nasal process of the maxilla is severed with a fine saw or a chisel. The periosteum is divided along the infra-orbital ridge, and elevated from the floor of the orbit, at the same time detaching the origin of the inferior oblique muscle of the eyeball. The medial part of the floor of the orbit is then divided with a small chisel. The malar (*zygomatic*) bone is next severed at its middle with a small saw or chisel, and in a line which extends obliquely downward and lateralward. The saw is carried through the floor of the orbit until it reaches the spheno-maxillary (*inferior orbital*) fissure. The malar (*zygomatic*) bone can be divided with strong bone forceps, which, however, should not be allowed to extend into the spheno-maxillary (*inferior orbital*) fissure. If the forceps are inserted too deep into the fissure, the internal maxillary artery may be severed.

Next extract the central incisor on the diseased side, divide the muco-periosteum of the floor of the nose close to the nasal septum, sever the muco-periosteum of the hard palate in the median line, and completely separate the soft palate from the hard palate. With a slender saw or bone cutting forceps introduced through the nose, divide the hard palate close to the nasal septum.

With one blade of the forceps at the infra-orbital ridge and the other at the alveolar process, grasp the maxilla with lion-jaw forceps, and loosen it from the

remaining attachments. This procedure fractures the vertical plate of the palatine bone, and detaches the maxilla from the pterygoid process of the sphenoidal bone.

The vessels ruptured or divided in removing the maxilla are branches of the third portion of the internal maxillary artery. They are: the alveolar, the infra-orbital, the posterior (*greater*) palatine, the pterygo-palatine (*pharyngeal branch*) and naso-palatine (*spheno-palatine*) arteries, or some of their branches. The actual cautery may be required to check hemorrhage. The cavity may be packed with gauze, and the wound in the skin closed. The gauze is subsequently removed through the mouth.

Excision of the mandible is performed for the removal of malignant growths of that bone. Usually only half of the bone is excised. Segments of the mandible are removed in extirpation of benign tumors of that bone. The incision is carried from the attached margin of the lower lip down the middle of the chin to the lower margin of the mandible, thence just below and parallel with the body of the mandible to the angle, and thence upward along the posterior margin of the ramus of the mandible to the level of the lobule of the ear. In making this incision the facial (*external maxillary*) artery is secured between ligatures before it is divided. The skin and superficial fascia, the platysma muscle, and the deep fascia are divided, carefully avoiding the parotid, the submaxillary, and the sublingual glands, and Stenson's (*parotid*) duct.

Beginning at the symphysis, the soft tissues are detached from the lateral surface of the bone with a periosteal elevator. The depressor labii inferioris (*quadratus labii inferior*), depressor anguli oris (*triangularis*), the buccinator, and the masseter muscles are thus separated from the bone (Plate CCXXXIII.)

After extracting one of the incisor teeth divide the bone with a small saw. Draw the divided end of the bone outward, and divide the mylo-hyoid muscle and mucous membrane of the mouth close to the bone, being careful to avoid injuring the sublingual or submaxillary gland or the lingual nerve. Now detach the internal pterygoid muscle from the bone with a periosteal elevator, and divide the internal lateral (*temporo-mandibular*) ligament of the mandible and the inferior dental (*alveolar*) vessels and nerve.

The mandible is now depressed so as to bring the coronoid process into view. Divide this process with a chisel and mallet, and dissect it out afterward, or divide the tendon of the temporal muscle with curved scissors. The tendon of the external pterygoid muscle is divided with scissors or detached with a periosteal elevator. Divide the capsular ligament and, after severing some few remaining attachments, such as the stylo-mandibular ligament, the bone can be removed. After bleeding has been checked the wound is closed.

The structures to be avoided in this operation are: the three salivary glands, Stenson's (*parotid*) duct, the buccal and supramandibular branches of the facial nerve, the lingual and auriculo-temporal nerves, the external carotid, the temporal and internal maxillary arteries, and the temporo-maxillary (*posterior facial*) and internal maxillary veins. The vessels which must be divided are: the facial (*external maxillary*), the inferior labial, the mental, the mylo-hyoid, the inferior dental (*inferior alveolar*), and the masseteric arteries and veins.

Excision of the condyle of the mandible is most commonly performed for disease of the temporo-maxillary (*mandibular*) articulation causing impaired movement of the mandible.

A vertical incision is carried from the zygoma downward over the condyle of the mandible to a point just above the position of the transverse facial artery, which is one centimeter (about one-half inch) below, and parallel with the zygoma. The length of this vertical incision is extremely important since if it is carried too far the facial nerve may be injured. A second incision is carried forward along the lower margin of the zygoma for two and a half centimeters (one inch). Reflect the flap thus outlined forward and downward, avoiding the temporal branches of the facial nerve. The retraction, if severe, may temporarily paralyze the upper facial fibers. Then detach the posterior fibers of the masseter muscle from the zygoma, and open the capsule of the temporo-maxillary (*mandibular*) joint.

The neck of the condyle is divided with a chisel or a small saw, the condyle being firmly held with a small hook. Twist the condyle out of the glenoid (*mandibular*) fossa, and divide the external pterygoid tendon and the capsular ligament. Keep the instruments close to the bone, in order to avoid injuring the temporal, the internal maxillary, and the masseteric vessels, the auriculo-temporal and masseteric nerves, and the parotid gland.

Development of the Bones of the Skull.—The bones of the vault of the cranium are developed in membrane, and those of the base of the skull are formed in cartilage. Just before birth the bones of the vault are imperfectly ossified at their margins, so that they are joined by membrane instead of by sutures. This condition of the bones allows diminution in the diameters of the fetal skull at birth by overlapping of the bones of the cranial vault.

At birth the bones are incompletely ossified at the angles of the parietal bone, these membranous areas being known as fontanelles.

The **posterior fontanelle** (**occipital fonticulus**), triangular in shape, is bounded anteriorly by the membranous portion of the parietals and posteriorly by the angular superior extremity of the occipital bone. It closes during the first few months after birth.

The **anterior fontanelle** (**frontal fonticulus**) is a quadrilateral membranous interval between the anterior portions of the parietal bones posteriorly and the frontal bones anteriorly, the latter being still separated by the metopic suture. This space closes at about the latter half of the second year.

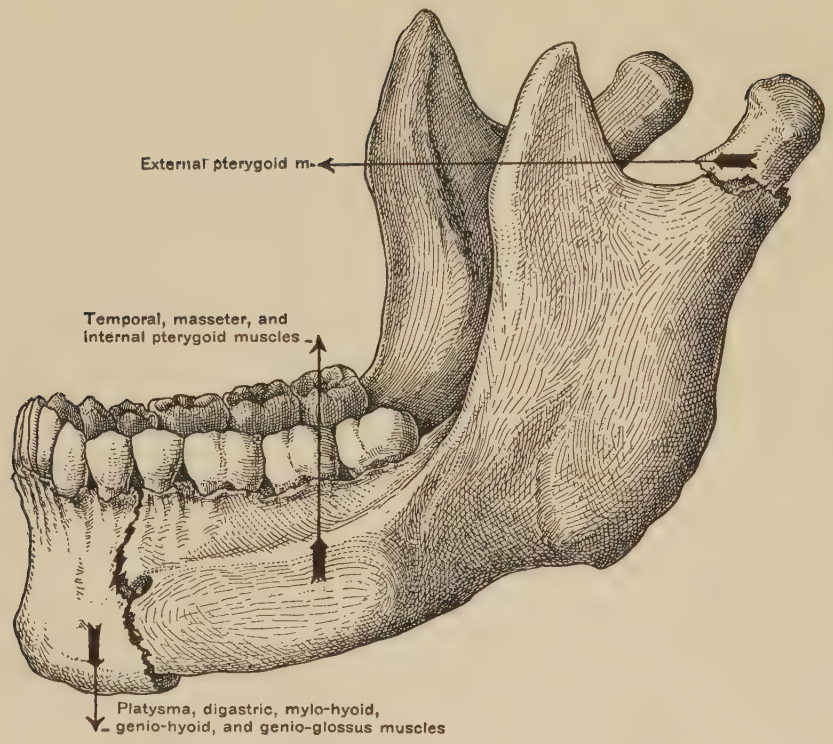
The **anterolateral fontanelles,** situated at the antero-inferior angles of the parietal bones, and the **posterolateral fontanelles,** situated at the postero-inferior angles of the parietal bones, close soon after birth. Imperfect or delayed ossification at the fontanelles occurs in hydrocephalus.

Fractures of the Skull.—The bones of the skull in young children are not readily fractured. When force is applied to the vault of the skull of an infant, it is merely indented, since ossification is so incomplete that the bones are flexible.

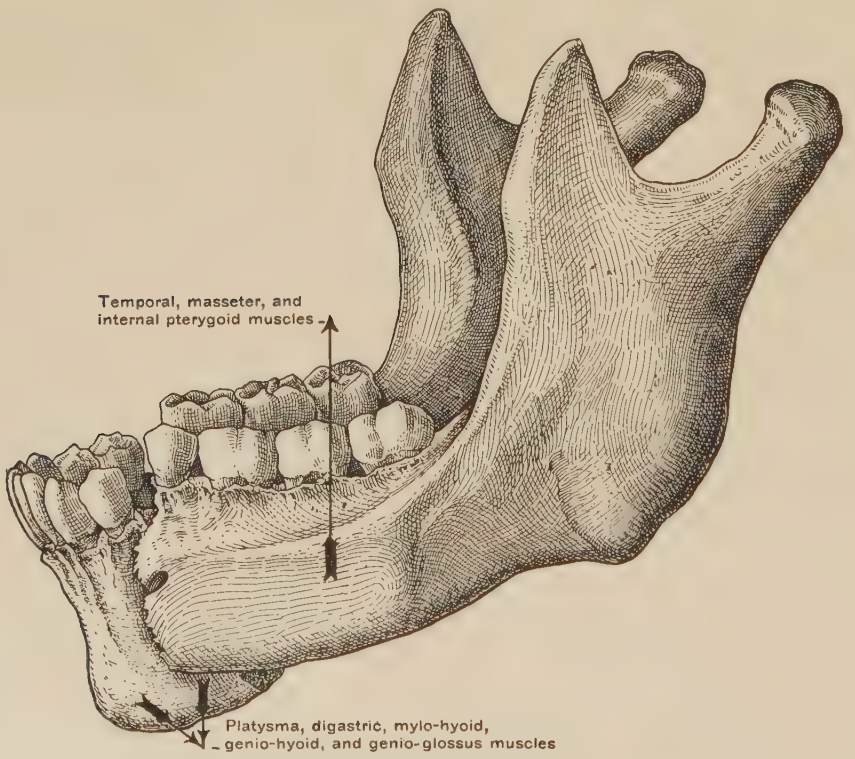
The adult skull is also not easily fractured, because its curves diffuse and diminish the fracturing force, and, being composed of three tables of different consistency, its strength and elasticity are much enhanced. Other conditions which lessen the danger of fracture of the vault of the cranium are: the mobility of the scalp proper, the rounded shape of the cranial vault, and the mobility of the head. As age advances the bones become less porous, less elastic, and, at about the fortieth year, the sutures begin to be obliterated by ossification of the intersutural membrane, and the skull then is more readily fractured. Either the external table or the internal table may be fractured without injury to the other table, but both tables are usually traversed by the fracture. On account of its brittleness and the diffusion of the force in passing through the bone, the internal table is much more splintered than the external. In depressed fractures of the vault the internal table may not be broken, the external table being merely driven into the diploë or one of the frontal sinuses.

Fractures of the vault of the skull are due to direct violence. A fracture of the vault resulting from diffuse application of force, as in a fall upon the head, usually extends to the base of the skull by the shortest route, regardless of sutures or thickness of the bones traversed. This is more likely to occur in a linear fracture. Fractures of the frontal region extend into the floor of the anterior cranial fossa, those of the parietal region into the floor of the middle cranial fossa, and those of the occipital region into the floor of the posterior cranial fossa.

Fractures of the base of the skull are caused by extension of a fracture from the vault of the skull and by direct or indirect violence. Fractures of the base by direct violence have been caused by foreign bodies having been driven through the roof of the orbit, the nose, or the pharynx. Fractures of the base by indirect violence usually result from the body falling upon the feet, the knees, or the buttocks, and from the upper part of the spinal column being driven against or through the occipital bone. In blows at the root of the nose the cribriform plate


External pterygoid m.
Temporal, masseter, and internal pterygoid muscles
Platysma, digastric, mylo-hyoid, genio-hyoid, and genio-glossus muscles

FRACTURE OF MANDIBLE AT NECK AND MENTAL FORAMEN.


Temporal, masseter, and internal pterygoid muscles
Platysma, digastric, mylo-hyoid, genio-hyoid, and genio-glossus muscles

BILATERAL FRACTURE OF MANDIBLE AT MENTAL FORAMINA.

of the ethmoidal bone may be fractured; and in a fall upon the chin the condyle of the mandible may be driven through the base of the skull at the middle cranial fossa. The cribriform plate of the ethmoidal bone has been known to be broken by contrecoup by a blow in the occipital region.

In fracture of the base of the skull at the *anterior cranial fossa* blood may enter the orbit and produce a subconjunctival ecchymosis, or blood and cerebro-spinal fluid may escape from the nose through the anterior nares or posterior nares and mouth. The blood escaping into the orbit is derived from ruptured meningeal vessels, anterior or posterior ethmoidal vessels, and the ophthalmic artery or vein; that entering the nose escapes from the anterior or posterior ethmoidal vessels, and the vessels of the nasal mucous membrane. In fracture of the cribriform plate of the ethmoidal bone rupture of the olfactory nerves may cause loss of the sense of smell. In fracture at the *middle cranial fossa* blood and cerebro-spinal fluid may escape from the ear. To permit cerebro-spinal fluid to escape in this manner, the arachnoid, dura mater, bone and mucous membrane of the wall of the tympanum, and membrana tympani must be ruptured. In fracture at the base of this fossa the cavernous sinus may be ruptured, and if the fracture extends across the petrous portion of the temporal bone, the superior petrosal sinus and the facial and auditory nerves may be injured. Laceration of the facial nerve causes paralysis of the muscles of expression and of the buccinator muscle; laceration of the auditory nerve causes deafness. In fracture of the base of the skull at the *posterior cranial fossa* blood may be extravasated into the tissues of the nape, or posterior triangle, of the neck (Battle's sign). The symptoms of fracture of the skull are chiefly those of compression of the brain, produced by extravasated blood which arises from rupture of the meningeal vessels, the sinuses of the dura mater, and the diploic veins.

Fractures of the Bones of the Face are the result of direct violence. In **fracture of the nasal bones** emphysema of the soft tissues may occur. In **fracture of the lacrimal bone** obstruction of the nasal duct may cause the tears to flow over the cheek, and laceration of the muco-periosteal wall of the duct may induce emphysema of the soft tissues. In **comminuted fracture of the zygomatic arch** fragments of bone driven into the temporal muscle may interfere with the movements of the mandible in mastication.

Fracture of the maxilla may cause profuse hemorrhage from a ruptured infra-orbital, superior dental (*superior alveolar*), anterior palatine, or posterior palatine artery.

Fracture of the mandible (Plate CCXXXVI) occurs more frequently than fracture of any other bone of the face. It is usually due to direct violence. In fracture of the *neck* of the mandible the condyle is drawn forward by the exter-

nal pterygoid muscle. Imperfect apposition and persistent mobility of the fragments may induce excessive formation of callus, whicy may subsequently cause more or less anklyosis of the temporo-maxillary (*mandibular*) articulation. In fracture of the *ramus* of the bone there is slight displacement of the fragments, since the masseter and internal pterygoid muscles act as splints. In fracture in front of the attachment of the masseter muscle the posterior fragment is drawn upward by the masseter, temporal, and internal pterygoid muscles; if the plane of fracture extends obliquely backward and lateralward, the posterior fragment is also drawn medialward by the internal pterygoid muscle. The anterior fragment is carried downward by the fracturing force and by the platysma, the digastric, mylo-hyoid, genio-hyoid, and the genio-glossus muscles. In *bilateral fracture at the mental foramina* the middle fragment is carried downward and backward by its weight, and by the digastric, the mylo-hyoid, and genio-glossus muscles. This displacement, which allows the base of the tongue to fall against the epiglottis, may produce asphyxiation.

DISSECTION OF THE NECK

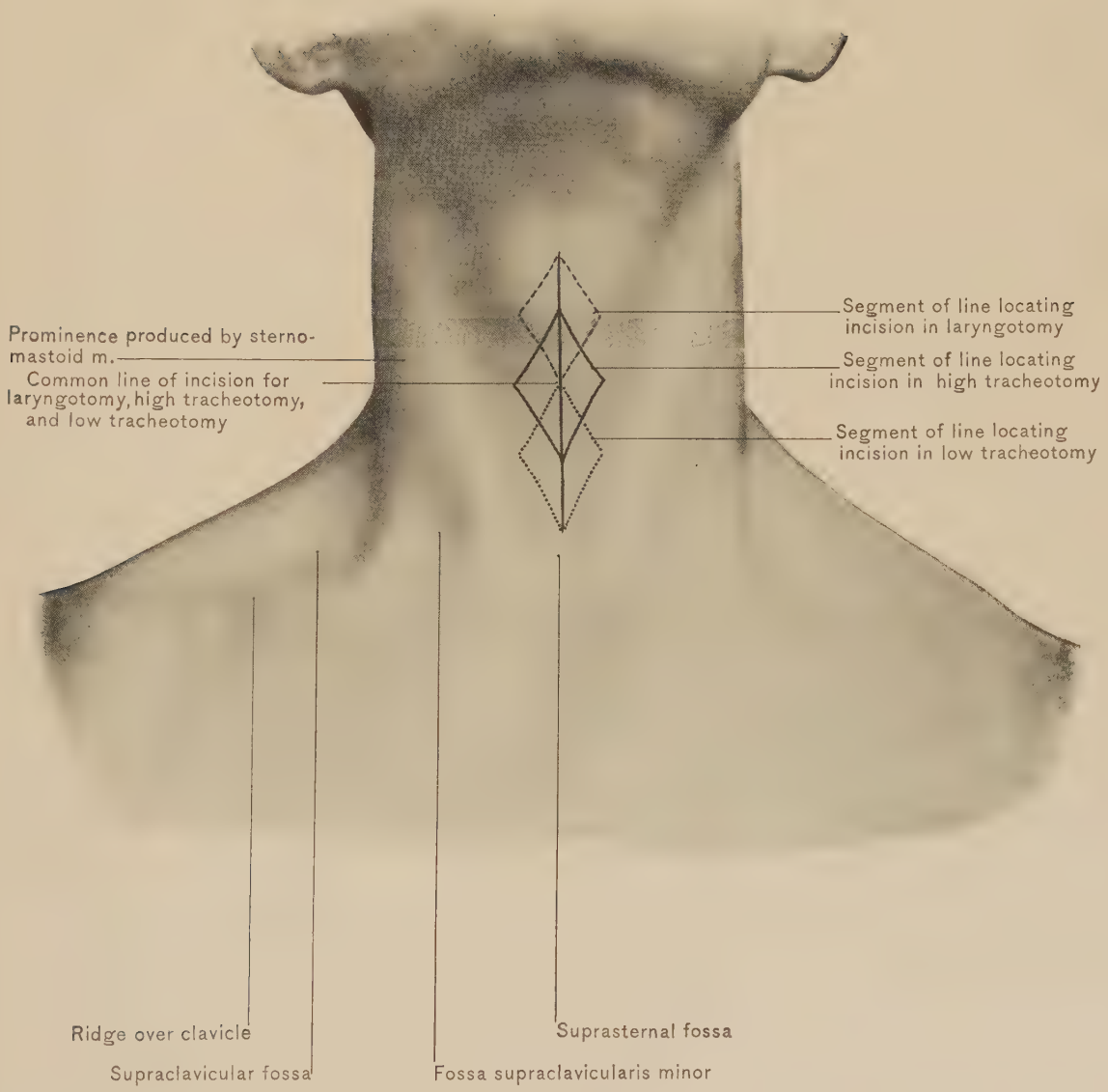
SURFACE ANATOMY

The surface anatomy of the region of the neck (Plate CCXXXVII) should be considered with regard to its superficial veins and nerves, the upper portion of the respiratory tract, the prominent muscles, the pulmonary apices, the sterno-clavicular joints, and the large vessels.

The **skin of the front of the neck,** which is thin and movable, usually lies in horizontal folds; in stout persons, owing to the deposition of fat in the subcutaneous tissues, these folds are very prominent, and produce the condition known as "double chin." Vertical folds occur in the aged, especially in those who have lost much adipose tissue, in consequence of which the old and inelastic skin can no longer adapt itself. The anterior and most prominent ridges of the surface of the neck are due to the anterior border of the platysma muscles.

Length of the neck.—The variability which exists in the length of the neck in different persons is due to three factors: to the position of the shoulder girdle; the contour of the border of the trapezius muscle, and to the thickness of the neck. The superior thoracic aperture is oblique from behind forward and downward; in some persons this obliquity is greater than in others, so that the suprasternal (*jugular*) notch may be on a level with the third thoracic vertebra, thus causing the sternal end of the clavicle to lie lower and making the neck appear longer. When the border of the trapezius muscle, instead of curving rather

PLATE CCXXXVII.


Prominence produced by sterno-mastoid m.
Common line of incision for laryngotomy, high tracheotomy, and low tracheotomy
Segment of line locating incision in laryngotomy
Segment of line locating incision in high tracheotomy
Segment of line locating incision in low tracheotomy
Ridge over clavicle
Supraclavicular fossa
Fossa supraclavicularis minor
Suprasternal fossa

SURFACE ANATOMY OF NECK, AND LINES OF INCISION IN LARYNGOTOMY, HIGH TRACHEOTOMY, AND LOW TRACHEOTOMY.

abruptly lateralwards, slopes gradually toward the shoulder, the neck will appear longer; a thin neck presents a longer appearance than a thick, muscular one.

The length of the cervical portion of the spinal column does not vary appreciably in different individuals.

The **sterno-mastoid muscle,** because of its prominence throughout its course, is the main landmark of the neck, and extends from the sterno-clavicular articulation to the mastoid process. It divides each lateral half of the neck into the anterior and posterior triangles. Any movement of the head which draws the ear downward and forward renders the muscle prominent. In subcutaneous section of the lower attachments of this muscle it must not be forgotten that the *fossa supraclavicularis minor,* the triangular interval between the sternal and clavicular origins, marks the position of the common carotid artery and the internal jugular vein.

The **suprasternal fossa** (**jugular notch**), the "*fonticulus gutturis*" of the old writers, lies between the sternal origins of the two sterno-mastoid muscles. On deep pressure with the finger in the suprasternal notch, the pulsations of the innominate artery and of a dilated aortic arch can often be felt. Retraction of the tissues in the suprasternal notch during inspiration is often seen in marked dyspnea, as in laryngeal obstruction.

The **sterno-clavicular joint** may be readily identified at the side of the suprasternal notch. Its upper border marks the origin of the innominate vein upon both sides, behind which, on the left side, lies the common carotid artery, and on the right side, the bifurcation of the innominate artery; still farther back is the apex of the lung. The innominate artery is relatively higher in children than in adults.

The **apex of the lung** extends from two and a half to five centimeters (one to two inches) above the upper border of the first costal cartilage and about two centimeters (three quarters of an inch) above the clavicle, and higher in very long necks. It is higher in women than in men due to the greater obliquity of the first rib. It is covered by part of the scalenus anterior, the sterno-thyroid, and the sterno-mastoid muscles, and to the medial side of the scalenus anterior muscle it is crossed transversely by the subclavian vessels. This portion of the lung is a common site of tuberculous invasion, and should be examined by percussion and auscultation immediately above and below the sternal end of the clavicle.

The **supraclavicular fossa** is the broad, flat depression above the clavicle between the sterno-mastoid and trapezius muscles. The external jugular vein terminates here, coursing from the angle of the mandible to the middle of the clavicle. The fossa is well defined in emaciated individuals and may be made more prominent by shrugging the shoulders. It marks the place where the

vessels and nerves pass from the neck into the axilla, and a knife thrust postero-inferiorly and medially through this depression would injure a number of important structures. The transverse processes of the lower cervical vertebræ may be felt by pressure directed medialward through the upper part of the fossa. In thin persons, especially during deep inspiration, the posterior belly of the omo-hyoid muscle can also be felt in this space, just above and parallel to the clavicle. During inspiration the tension produced by the omo-hyoid muscle on the deep cervical fascia is plainly discernible. Its central tendon is often likened to a rudimentary cervical rib, its posterior belly to a digitation of the serratus magnus (*serratus anterior*) muscle, and its anterior belly to a sterno-hyoid muscle. Under its posterior belly are found the cords of the brachial plexus, and nearer the clavicle is the subclavian artery.

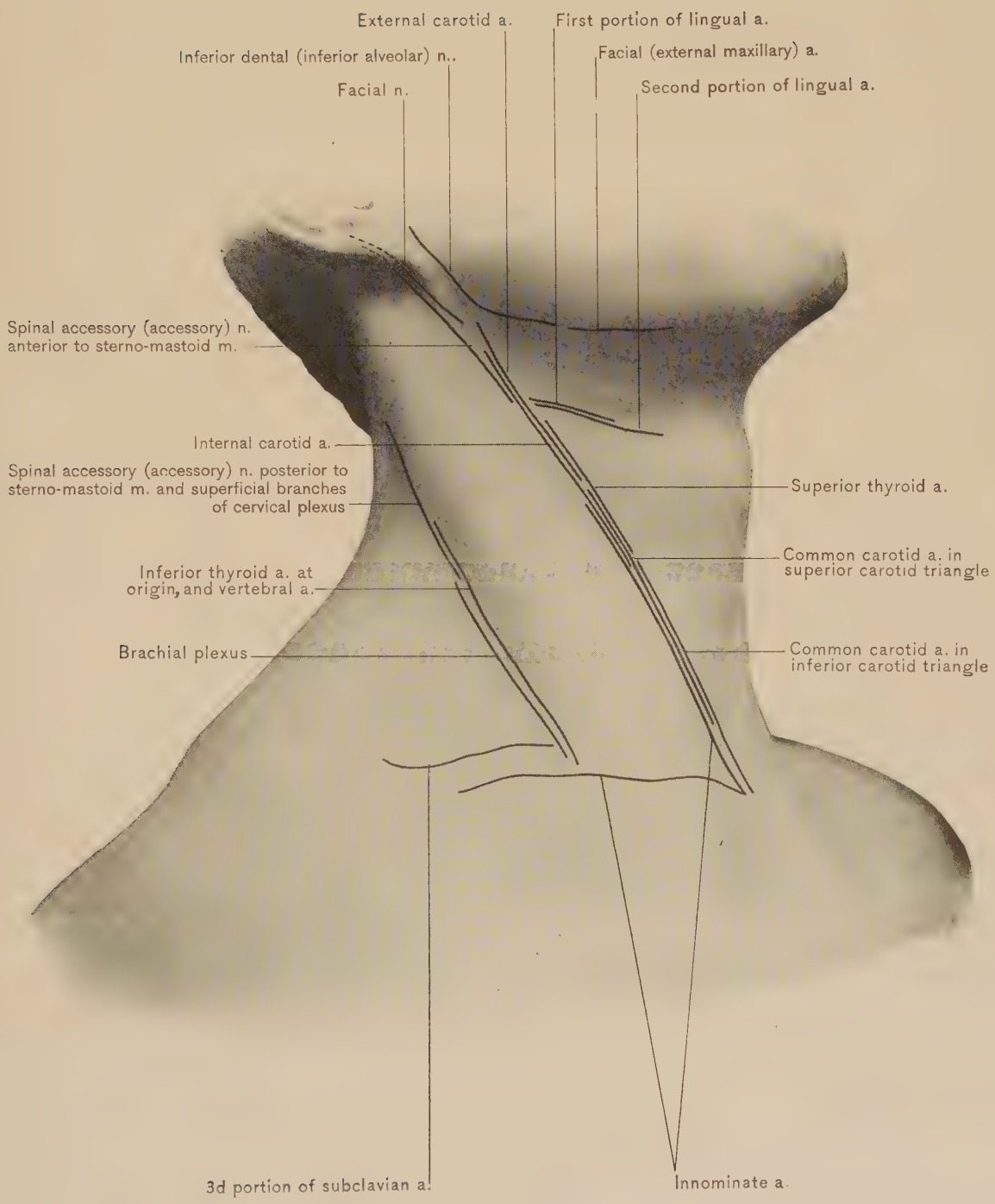
The **subclavian artery** extends from one to three centimeters (one-half to one inch) above the clavicle, in the supraclavicular fossa, close to the lateral border of the sterno-mastoid muscle, where, by moderate pressure, directed infero-posteriorly and medialward, it can readily be compressed against the first rib; pressure directed otherwise would meet no bony resistance, and bleeding could not be controlled.

The **carotid arteries** (Plate CCXXXVIII) are readily found in the neck along the anterior, or medial, margin of the sterno-mastoid muscle, being covered by its anterior border, particularly in the lower part of the neck. The *common carotid artery* divides opposite the upper border of the thyroid cartilage. From this point at the anterior border of the sterno-mastoid muscle, a line drawn to the lobe of the ear indicates the course of the *external carotid artery*. The position of the common carotid artery is represented by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the mandible and the mastoid process.

The **external jugular vein** passes down the neck in a line drawn from the angle of the mandible to the middle of the clavicle. By compression of its lower end the vein may be made to stand out prominently. Occasionally, a *jugulo-cephalic branch* passes over the clavicle from the cephalic to the external jugular vein. The **anterior jugular vein** is usually found near the anterior margin of the sterno-mastoid muscle.

The **hyoid bone** and its cornu can be felt in the space between the lower border of the chin and the front of the neck in the ordinary attitude of the head. To its upper border are attached the base of the tongue and the genio-hyoid and mylo-hyoid muscles, which form the floor of the mouth. Below the body of the bone are the thyro-hyoid space and membrane; the center of the latter corresponds to the position of the epiglottis. The greater cornu of the bone is the landmark

PLATE CCXXXVIII.


External carotid a.
First portion of lingual a.
Inferior dental (inferior alveolar) n..
Facial (external maxillary) a.
Facial n.
Second portion of lingual a.
Spinal accessory (accessory) n. anterior to sterno-mastoid m.
Internal carotid a.
Spinal accessory (accessory) n. posterior to sterno-mastoid m. and superficial branches of cervical plexus
Superior thyroid a.
Common carotid a. in superior carotid triangle
Inferior thyroid a. at origin, and vertebral a.
Brachial plexus
Common carotid a. in inferior carotid triangle
3d portion of subclavian a.
Innominate a.

LINES OF INCISION FOR EXPOSURE OF ARTERIES AND NERVES OF NECK.

which locates the origin of the superior thyroid, lingual, and facial arteries. The origin of the superior thyroid artery is just below the level of the greater cornu of the hyoid bone, that of the lingual artery is opposite, and that of the facial artery is just above the greater cornu.

The **thyroid cartilage** forms the anterior projection in the neck, called "Adam's apple" or *pomum Adami (laryngeal prominence);* it is larger in men than in women, so that there is increased length of the vocal cords, and in accordance with a well-established law of physics, a lower pitch, thus accounting for the deeper tones of the male voice. The entire cartilage is subcutaneous, its borders and cornua being easily traced with the finger. The lateral lobes of the thyroid gland can be indistinctly felt upon each side of the cartilage, and sometimes the pulsations of the superior thyroid artery can be felt at the tip and front of the lateral lobe. Below this cartilage is the crico-thyroid space, which is occupied by the crico-thyroid membrane. It is through this membrane that laryngotomy is performed, care being taken to hug the upper border of the cricoid cartilage, so that the incision may be as far as possible from the vocal cords and the crico-thyroid arteries. But, as Jackson has shown, this space should not be used except in an emergency, low tracheotomy being the preferable operation.

The **vocal cords** are situated slightly below a point midway between the deepest part of the incisura thyroideæ and the lower border of the thyroid cartilage.

The **cricoid cartilage** is always prominent, and can readily be discerned. It lies opposite the sixth cervical vertebra. The transverse process of this vertebra is called the carotid, or Chassaignac's, tubercle and is the location of choice for digital carotid compression. It also marks the point of entrance of the vertebral artery into the bony canal. The lower border of the cartilage is on a level with the commencement and narrowest part of the esophagus; for this reason all bodies which have entered the pharynx but are too large to pass through the gullet will lodge behind the cricoid cartilage. The cricoid cartilage is just above the level at which the omo-hyoid muscle and the inferior thyroid artery cross the carotid sheath, the muscle being anterior, and the artery posterior to the sheath.

The **movements of the larynx** are frequently overlooked. The larynx rises during deglutition, in singing a high note, and in expiration; it descends in singing low notes, in inspiration, after deglutition, and during retching and vomiting. When the larynx is moved from side to side, it produces a grating sensation, due to the friction of the superior cornua of the thyroid cartilage against the spinal column. The larynx is pushed forward as food masses pass through the lower pharynx. The sudden upward rush of vomited matter produces suction upon the larynx, loosening any obstinately adherent false membrane and collections of glairy mucus; this is one reason for giving children emetics in croup.

The **trachea** is situated immediately below the cricoid cartilage and only one or two of the upper rings are palpable. Ordinarily not more than about four centimeters (one and a half inches) (Plate CCXXXVII) of it appear above the sternum; but with the neck in extreme tension about two and a half centimeters more are gained. This usually leaves about eight rings in the neck, of which the second, third, and fourth are covered by the thyroid isthmus. The front of the trachea may lie four centimeters deep at the top of the sternum, owing to the recession of the lower cervical and upper thoracic vertebræ. Opening of the trachea to relieve dyspnea is beset with many difficulties not all of which are demonstrable in the cadaver, such as the strong and rapid alternate muscular contractions, the heaving larynx, the distended anterior jugular veins, the flexed neck, the swollen thyroid isthmus, the distended thyroid plexus of veins, and frequently, a middle thyroid (*thyroidea ima*) artery. All incisions into the trachea should be in the median line, where fewer important structures need be severed. It may be advisable in cases of dyspnea to incise the crico-thyroid membrane, and, if necessary, the cricoid cartilage may be divided, but a low operation should be done when the patient has become quieted after relief of the dyspnea, so that laryngeal stenosis does not result.

In the **back of the neck** are: above, the external occipital protuberance and the superior curved ridges (*superior nuchal lines*) of the occipital bone; below, the spinous process of the seventh cervical vertebra (vertebra prominens) and the ligamentum nuchæ, extending between the protuberance and the spine of the seventh cervical vertebra. For two and a half centimeters (one inch) below the superior curved ridges (*superior nuchal lines*) of the occipital bone the thin cerebellar fossæ of the occiput are less than two centimeters (three quarters of an inch) from the surface; their walls are so thin that at times they may easily be penetrated with a sharp knife. About two and a half centimeters below the external occipital protuberance a sharp, narrow instrument can be pushed forward, either above or below the posterior arch of the atlas, thus severing the upper end of the spinal cord and destroying life. About four centimeters (one and a half inches) on each side of the external occipital protuberance, the occipital artery pierces the trapezius muscle, below the superior curved ridge (*superior nuchal line*), and passes over the occiput to the vertex; it is accompanied by the greater occipital nerve. The lateral margin of the trapezius muscle merges with the shoulder as it passes to it, and forms the graceful outline of the neck. Deep pressure in the median line near the occiput reveals the bifid spine of the second cervical vertebra. The spines of the third, fourth, and fifth cervical vertebræ, because of their shortness and recession, are not readily felt. The spines of the sixth and, more especially, of the seventh cervical vertebræ may easily be detected. The fifth cervical

spine is opposite the cricoid cartilage and the upper end of the esophagus; that of the seventh is behind the apex of the lung, which is higher in women.

Congenital cervical fistulæ.—A brief *resumé* of the development of the neck is here introduced in order to explain certain interesting and important congenital defects.

The anterolateral portion of the neck is formed largely from the *branchial*, or *visceral*, arches, four in number on each side, connected posteriorly with the spinal column, but not at first uniting anteriorly with one another. These arches are separated from one another by the branchial clefts, also four in number on each side, the fourth one being below the last arch.

The first, or mandibular, arch is concerned in the formation of the maxillæ; it is separated from the second arch by the first branchial cleft, which is the only cleft remaining in the adult.

The first branchial cleft persists as the external auditory meatus, the middle ear, and Eustachian (*auditory*) tube. Irregularities in development may lead to the formation of fistulous openings, which are usually found in the vicinity of the tragus of the ear.

The lower three arches are concerned in the formation of the tissues of the neck.

The visceral clefts open internally into the pharynx; no communication of the pharynx with the exterior ever occurs, for a delicate membrane divides the cleft into a medial (pharyngeal pouch) and a lateral portion (branchial furrow).

The lower three clefts normally disappear, certain traces found in the pharynx and larynx alone remaining.

The third and fourth arches are small, are gradually overlapped by the second arch, and lie in a depression known as the *sinus cervicalis*. It is through imperfect closure of this sinus that most of the congenital cervical fistulæ occur. These are narrow tracts lined with epithelium, opening externally near the anterior border of the sterno-mastoid muscle. When complete, they open internally into the pharynx. If the internal portion of a branchial cleft fails to become obliterated, while the outer portion is closed as normally, a *pharyngeal* or *esophageal diverticulum* may form. Furthermore, if the cleft becomes closed externally and internally and an intermediate, unobliterated portion persists, the epithelial lining of this cavity may proliferate and undergo various changes, producing a so-called *branchial cyst*, or hygroma. These branchial cysts occur in the submaxillary and supraclavicular regions and at the borders of the sterno-mastoid muscle. Cysts and fistulæ of the thyro-glossal duct may also be found. The anterior portion of the tongue, which originates in the floor of the pharynx between the anterior ends of the first branchial arches, gradually grows forward into

the buccal cavity. The posterior portion of the tongue arises from the second pair of branchial arches. Between these is found the forerunner of the portion of the thyroid gland which forms the thyro-glossal duct, while a portion becomes the gland proper. The duct usually begins to atrophy in the fifth week of intra-uterine life and is closed by the eighth week, but, as in the tunica vaginalis, any anomaly may present itself.

Dissection.—With the body on its back, the neck should be extended and made prominent by placing a block beneath the shoulders (Plate CCXXXIX). An incision should be carried from the symphysis of the mandible down the middle line of the neck to the middle of the top of the sternum; a second should be made along the clavicle to the acromion process, and a third one along the lower border of the mandible to the angle of the jaw, thence to the lobe of the ear, and behind the ear to the transverse incision made in dissecting the scalp. The face should then be turned away from the side on which the dissection is being made, and retained in position with hooks, the skin being raised and reflected from before backward to beyond the anterior border of the trapezius muscle.

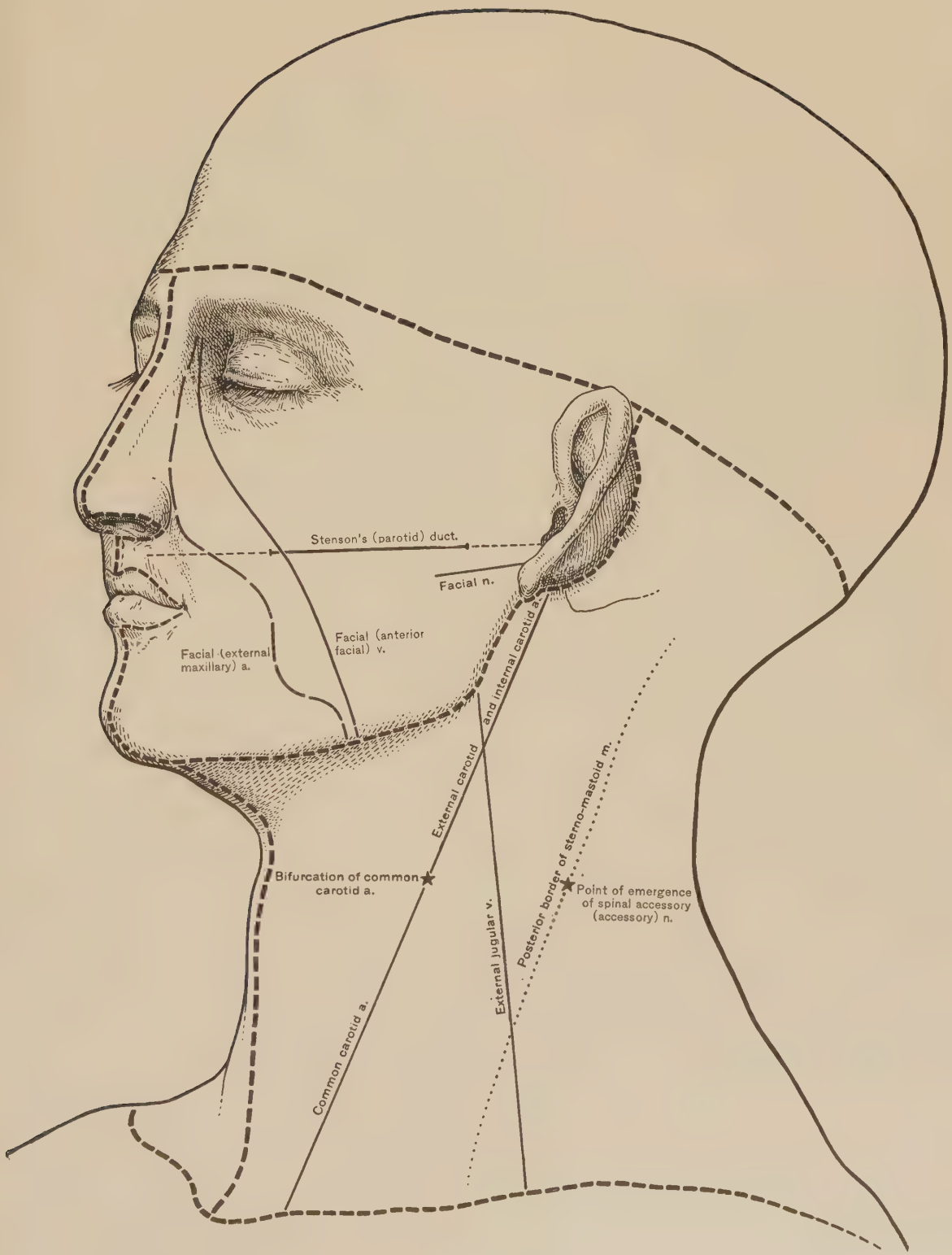
The **skin covering the side of the neck** is elastic and thin, and can readily be raised into folds, which always contain the platysma muscle; these conditions favor the performance of plastic operations. It differs from the skin over the nape of the neck, which is very dense and adherent, and more freely supplied with nerves, but not nearly so well supplied with blood vessels. *Carbuncles* often develop at the lower part of the nape of the neck near the median line.

The **superficial fascia** now exposed is a very thin lamina of areolar and adipose tissue, divided into two layers, the deep one being a very delicate layer of laminated tissue. Between these two layers are the platysma muscle, the external, anterior, and posterior external jugular veins, the superficial branches of the cervical plexus of nerves, and the inframandibular (*cervical*) branch of the cervico-facial division of the facial nerve.

Dissection.—The superficial layer of the superficial fascia should be removed in the same manner as in reflecting the skin. This dissection exposes the platysma muscle.

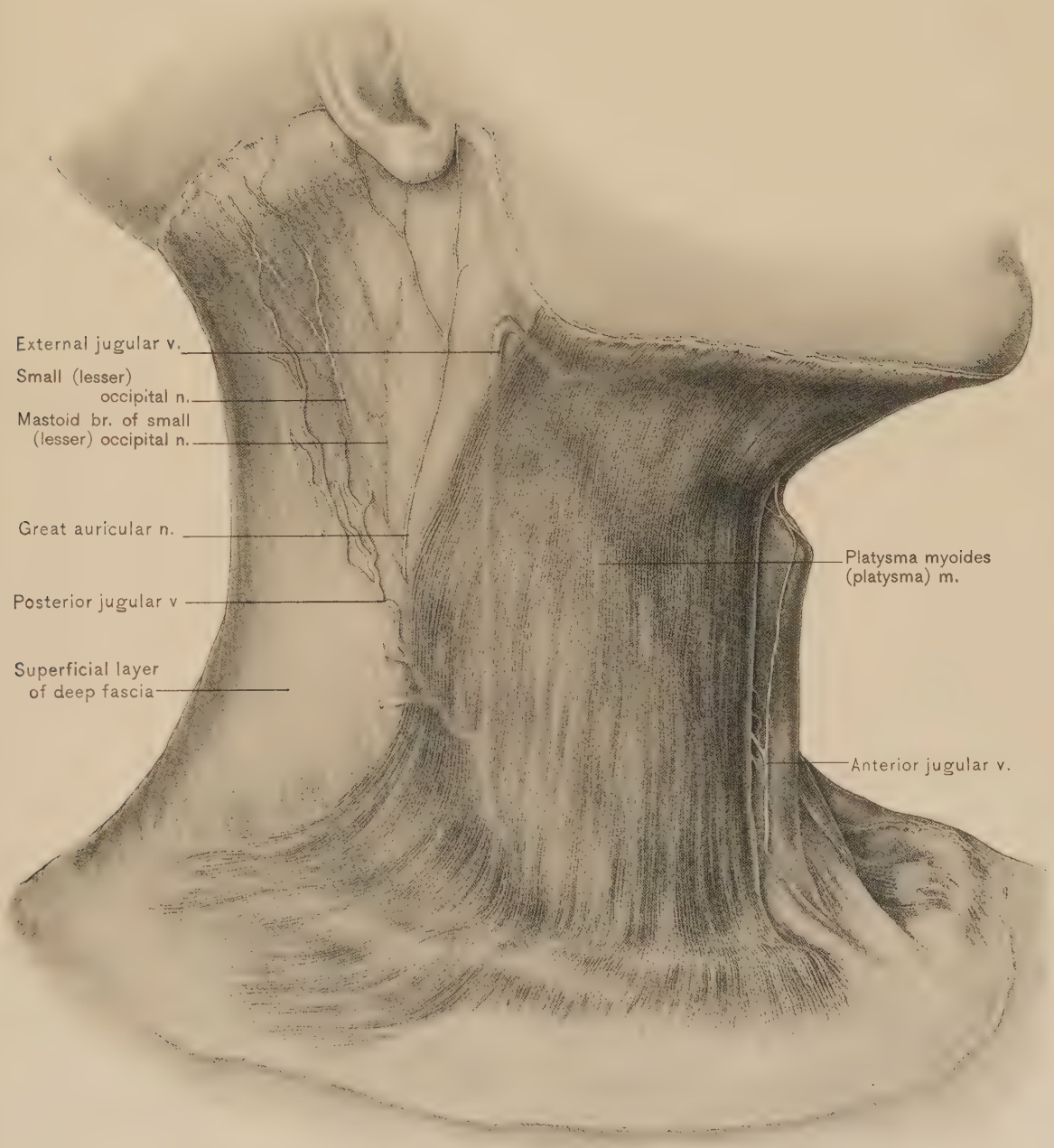
The **platysma muscle** (Plate CCXL), a broad, thin muscle, lies immediately beneath the skin and is closely connected to it by the superficial layer of the superficial fascia; it covers the front and side of the neck, extending from the summit of the shoulder and front of the chest to the face. This muscle is a member of the panniculus carnosus group. It *arises* from the deep fascia covering the pectoralis major, the deltoid, and the trapezius muscles, and ascends obliquely forward along the side of the neck, for *insertion* into the inferior border of the mandible, the superficial fascia of the cheek, the muscles at the angle of the mouth,

PLATE CCXXXIX.


Stenson's (parotid) duct.
Facial n.
Facial (external maxillary) a.
Facial (anterior facial) v.
External carotid and internal carotid a.
Bifurcation of common carotid a.
Point of emergence of spinal accessory (accessory) n.
Posterior border of sterno-mastoid m.
External jugular v.
Common carotid a.

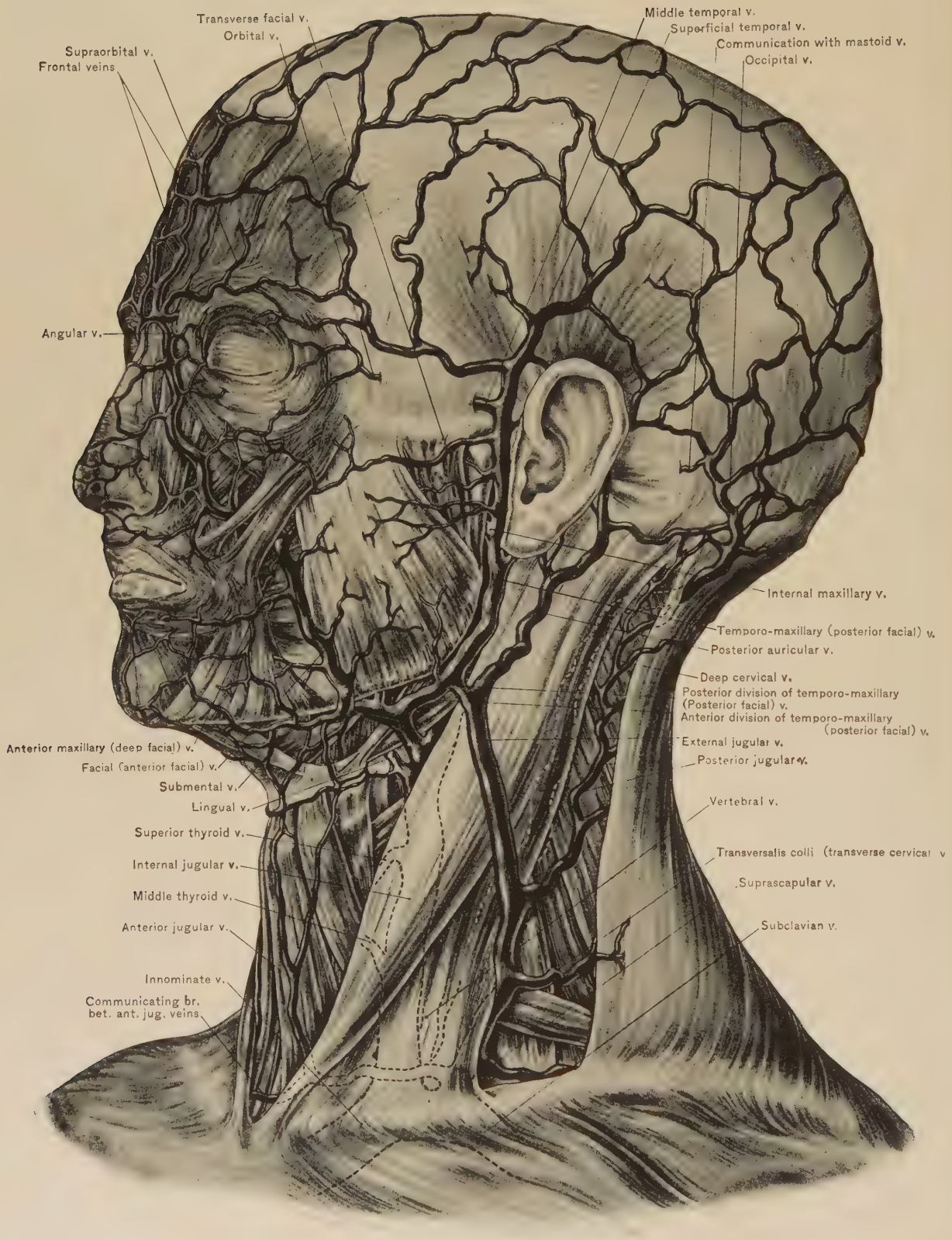
INCISIONS FOR DISSECTION AND LINES FOR VESSELS AND NERVES.

PLATE CCXL.


External jugular v.
Small (lesser) occipital n.
Mastoid br. of small (lesser) occipital n.
Great auricular n.
Posterior jugular v
Superficial layer of deep fascia
Platysma myoides (platysma) m.
Anterior jugular v.

PLATYSMA MYOIDES (PLATYSMA) MUSCLE.

PLATE CCXLI.



VEINS OF SCALP, FACE, AND NECK.

and the integument of the chin. The anterior fibers cross those of the opposite side just below the symphysis of the mandible, and are *inserted* into the integument of the chin; the intermediate fibers are attached to the inferior border of the mandible; the posterior fibers are prolonged over the masseter muscle, and are *inserted* into the superficial fascia of the cheek and the muscles at the angle of the mou th. The fibers passing transversely to the angle of the mouth constitute the **risorius muscle.**

Nerve Supply.—From the inframandibular (*cervical*) branch of the cervico-facial division of the facial and the superficial cervical nerves.

Blood Supply.—From the vessels ramifying in the superficial fascia of the neck.

Action.—It draws the lower lip downward and lateralward by contraction of its upper fibers; when all the fibers are contracted, however, the skin and superficial fascia of the neck between the clavicle and the mandible are raised, being made taut between these two bones; it also helps to depress the mandible; when the mandible is fixed it assists the opposite sterno-mastoid muscle in flexion and rotation of the head toward its own side. The anterior edge of the muscle is distinctly visible in emaciated and aged persons, and, with the platysma of the opposite side, forms two divergent folds descending from a little below the chin. As the muscle dips into a depression above the clavicle, by elevation of the skin and fasciæ at the root of the neck, it relieves pressure upon the veins and favors return circulation.

Injuries of the neck, with destruction of considerable portions of the integument and platysma, as in burns, are usually followed by deformity from cicatricial contraction. Pus in the loose tissues under the platysma may burrow extensively, descending from the submaxillary region to the upper part of the chest-wall, where pointing may occur.

Dissection.—The platysma should now be removed, cutting it across near the clavicle and reflecting it upward to its insertion into the mandible, thus exposing the subcutaneous portions of the superficial branches of the cervical plexus of nerves, the inframandibular (*cervical*) branch of the cervico-facial division of the facial nerve, and the anterior, external, and posterior external jugular veins.

The **external jugular vein** (Plate CCXLI) arises in the substance of the parotid gland, and is formed by the union of the posterior auricular vein and the posterior division of the temporo-maxillary (*posterior facial*) vein. It runs down the neck in a *line* drawn from the angle of the mandible to the middle of the clavicle, first passing over the sterno-mastoid muscle, and then along its posterior border to the root of the neck, there piercing the superficial layer of the deep cervical fascia to enter the subclavian vein in the subclavian triangle. This fascia is so closely

attached to the vein that if the vein is divided at the root of the neck it will remain open. The **auricularis magnus** (**great auricular**) **nerve,** the largest branch of the superficial set of the cervical plexus, accompanies the vein in its upper part, and the superficial cervical branch of the same plexus passes beneath it at about the middle of the course of the vein. The posterior external jugular, the transverse cervical, and suprascapular (*transverse scapular*) veins empty into the external jugular vein. Near the angle of the mandible the external jugular communicates with the internal jugular vein by a large branch, and with the common facial vein; farther down it communicates with the anterior jugular, and, at times, with the cephalic vein by a branch, the *jugulo-cephalic*, which passes over the clavicle. The anterior jugular vein occasionally empties into the external jugular instead of into the subclavian vein. The external jugular vein contains one pair of valves at its point of entrance into the subclavian, and another pair at about four centimeters (one and a half inches) above this point; these valves do not prevent the reflux of blood into the external jugular vein, so that in certain cardiac and aortic diseases, especially in tricuspid insufficiency, a pulsation in the external jugular vein synchronous with the cardiac systole may be observed. The portion of the vein between the valves is dilated; this portion is called the **sinus.** The external jugular vein varies in size, being small when the anterior and posterior jugular veins are large, and vice versa. In some instances two external jugular veins may be observed upon each side of the neck.

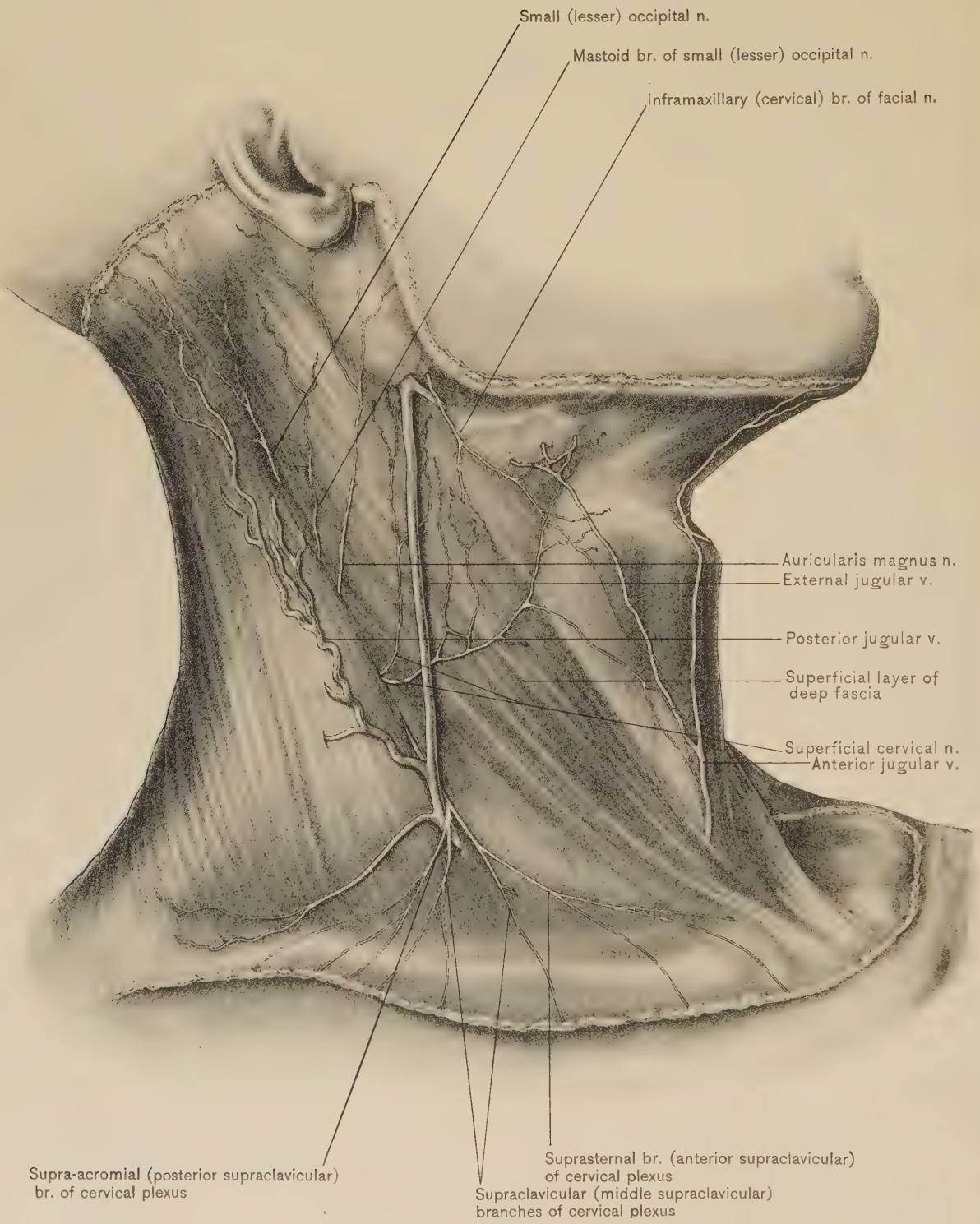
Although the external jugular was once a favorite site for phlebotomy, especially for congestions or inflammations of the head and neck, it is now only rarely utilized. In children whose antecubital vessels are extremely small it is still used for the introduction of solutions by the intravenous route.

A chain of four to six small lymph glands, the superficial cervical, lies along the course of the external jugular vein.

The **posterior external jugular vein** arises in the superoposterior part of the neck, between the splenius and trapezius muscles, draining this territory and entering the lower portion of the external jugular vein just after it crosses the sterno-mastoid muscle. It occasionally receives the occipital vein. In the fetus it drains the intracranial region through a vein transmitted by the post-glenoidal foramen, the remnant of which is the **mastoid vein.** The transverse cervical and suprascapular (*transverse scapular*) veins frequently empty into the posterior external jugular vein.

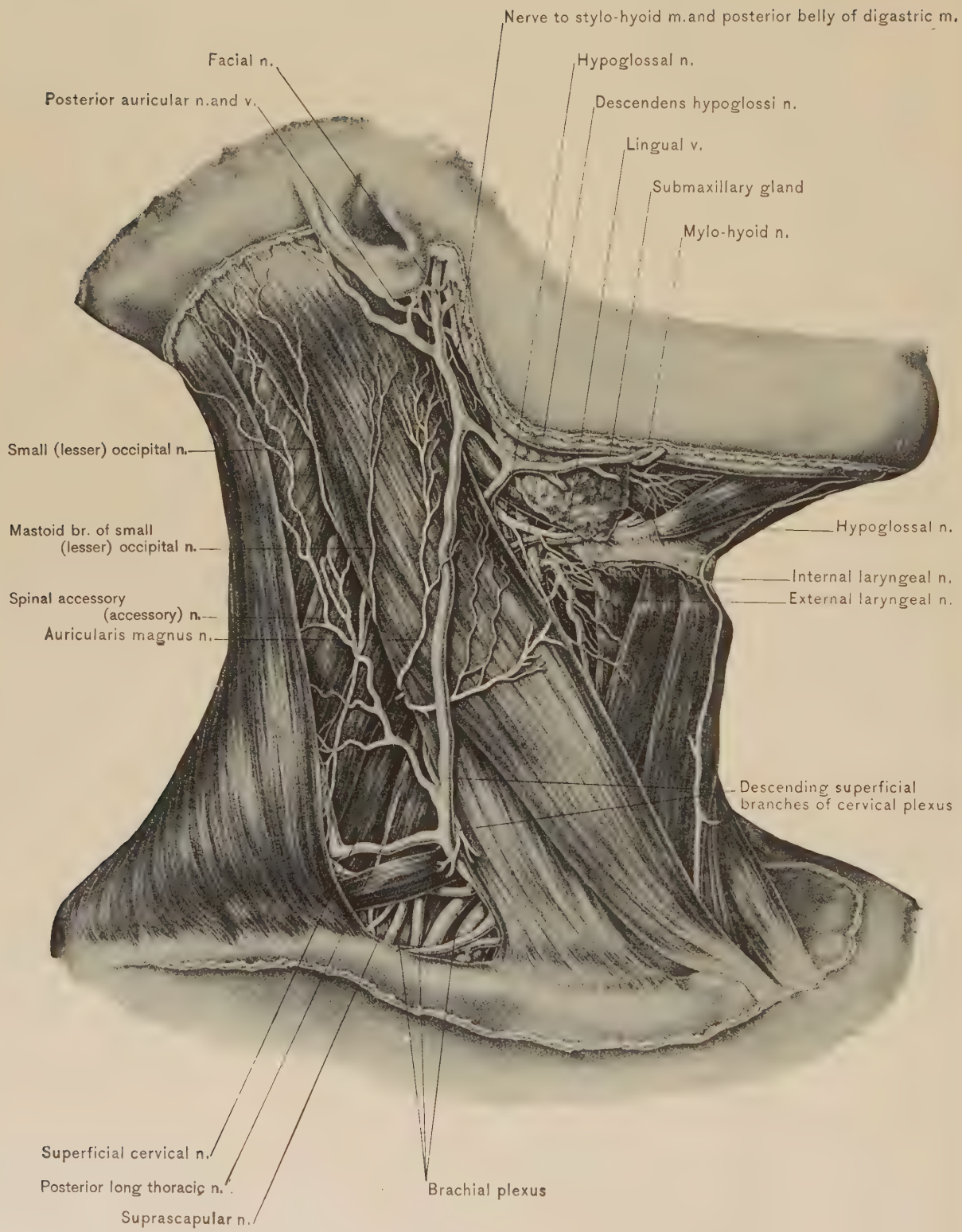
The **anterior jugular vein** arises beneath the chin upon the mylo-hyoid muscle. It is formed by the mental, submental, inferior labial, and inferior hyoid veins, and passes downward almost to the sternum, in advance of the anterior border of the sterno-mastoid muscle, and resting on the sterno-hyoid

PLATE CCXLII.


Small (lesser) occipital n.
Mastoid br. of small (lesser) occipital n.
Inframaxillary (cervical) br. of facial n.
Auricularis magnus n.
External jugular v.
Posterior jugular v.
Superficial layer of deep fascia
Superficial cervical n.
Anterior jugular v.
Supra-acromial (posterior supraclavicular) br. of cervical plexus
Suprasternal br. (anterior supraclavicular) of cervical plexus
Supraclavicular (middle supraclavicular) branches of cervical plexus

SUPERFICIAL LAYER OF DEEP FASCIA, SUPERFICIAL VEINS AND NERVES.

PLATE CCXLIII.



SUPERFICIAL NERVES OF NECK.

muscle. Here it pierces the superficial layer of the deep cervical fascia, and occupies the suprasternal intra-aponeurotic space of Burns, the interval above the sternum, made by the division of the superficial layer of the deep cervical fascia into two layers; it then turns lateralward beneath the sterno-mastoid muscle, and enters either the external jugular or the subclavian vein. It drains the skin and muscles of the anterior, or median, region of the neck. In making a subcutaneous section of the sterno-mastoid muscle for the correction of torticollis (wry-neck), the tenotome must hug the under surface of the origins of the muscle closely, otherwise the anterior, external, and internal jugular veins may be injured. There are usually two anterior jugular veins, one upon each side of the median line of the neck, connected just above the sternum by a transverse branch, *the venous jugular arch*. This branch also occupies the interval between the two layers of the superficial layer of the deep cervical fascia, and, being quite large at times, should be borne in mind when performing a low tracheotomy. In labored breathing, due either to laryngeal or tracheal obstruction, these veins will be much dilated, and care will be required in incising the median line of the neck, to prevent opening one or the other, an accident which, while not serious, may unnecessarily prolong a tracheotomy operation. Division of the transverse branch connecting the anterior jugulars at the root of the neck causes very free bleeding, and an inexperienced surgeon in performing his first tracheotomy, might be misled to think he had opened an anomalously high left innominate vein. The anterior jugular vein contains no valves, and its variation in size, in inverse proportion to the other jugular veins, should be remembered.

Dissection.—Next trace the superficial branches of the cervical plexus and the inframandibular (*cervical*) branch of the cervico-facial division of the facial nerve.

The **superficial branches of the cervical plexus of nerves** (Plates CCXLII; CCXLIII) are divided into the ascending, transverse, and descending branches. They are purely sensory in character. The ascending branches are the small occipital and the great auricular nerves. The transverse branch is the superficial (*cutaneous*) cervical nerve. The descending branches are the suprasternal (*anterior supraclavicular*), supraclavicular (*middle supraclavicular*), and supra-acromial (*posterior supraclavicular*) nerves.

The **small occipital** (**lesser occipital**) **nerve** arisesr fom the anterior division of the second or from the second and third cervical nerves. It may be single or double. Beneath the sterno-mastoid muscle it forms a loop which embraces the spinal accessory nerve, to which it also furnishes a branch, and emerges from beneath the posterior border of the sterno-mastoid just above the middle of the muscle. This loop acts as a guide in locating the spinal accessory nerve. The

small occipital nerve ascends along the upper half of the posterior border of the sterno-mastoid muscle to the occiput, where it pierces the superficial layer of the deep cervical fascia, dividing into auricular, mastoid, and occipital branches. It is distributed to the integument covering the occipitalis muscle, and communicates with the greater occipital, the great auricular, and the posterior auricular branch of the facial nerve.

The **great auricular nerve,** the largest of the superficial branches of the cervical plexus, arises from the anterior division of the second and third cervical nerves, and curves around the posterior border of the sterno-mastoid muscle immediately above the superficial nerve. Here it pierces the superficial layer of the deep cervical fascia, ascends in relation with the upper part of the external jugular vein, and passes obliquely over the sterno-mastoid and beneath the platysma muscle. Reaching the lobule of the ear, it divides into the following branches: *facial,* or *anterior, branches,* distributed to the skin over the parotid gland, and communicating with branches from the facial nerve through this gland, which it also supplies; *auricular,* or *posterior, branches,* distributed to the integument on the back of the auricle, and communicating with the posterior auricular branch of the facial and the auricular branch of the vagus nerve, and *mastoid branches,* distributed to the skin over the mastoid process, communicating with the small occipital and the posterior auricular branch of the facial nerve.

The **superficial** (**cutaneous**) **cervical nerve** is a branch of the anterior divisions of the second and third cervical nerves, usually arising in common with the great auricular. It winds around the middle of the posterior border of the sterno-mastoid muscle, pierces the superficial layer of the deep cervical fascia, and passes transversely over the muscle beneath the external jugular vein, receiving a communicating branch from the inframandibular (*cervical*) branch of the facial nerve. It divides into an *ascending branch,* which sends filaments to the external jugular vein, communicates with the inframandibular (*cervical*) branch of the facial nerve, and supplies the platysma muscle and the skin of the front of the neck as far as the chin; and a *descending branch,* which supplies the skin of the lower half of the front of the neck.

The **superficial descending branches of the cervical plexus** arise from the anterior divisions of the third and fourth cervical nerves, emerge from beneaht the posterior border of the sterno-mastoid muscle, pierce the superficial layer of the deep cervical fascia, and divide into the suprasternal (*anterior supraclavicular*), supraclavicular (*middle supraclavicular*), and supra-acromial (*posterior supraclavicular*) nerves. The anterior, or *suprasternal, twigs* pass over the clavicular and sternal origins of the sterno-mastoid muscle, and supply the integument over the sternal end of the clavicle and the upper part of the sternum; the middle,

PLATE CCXLIV.

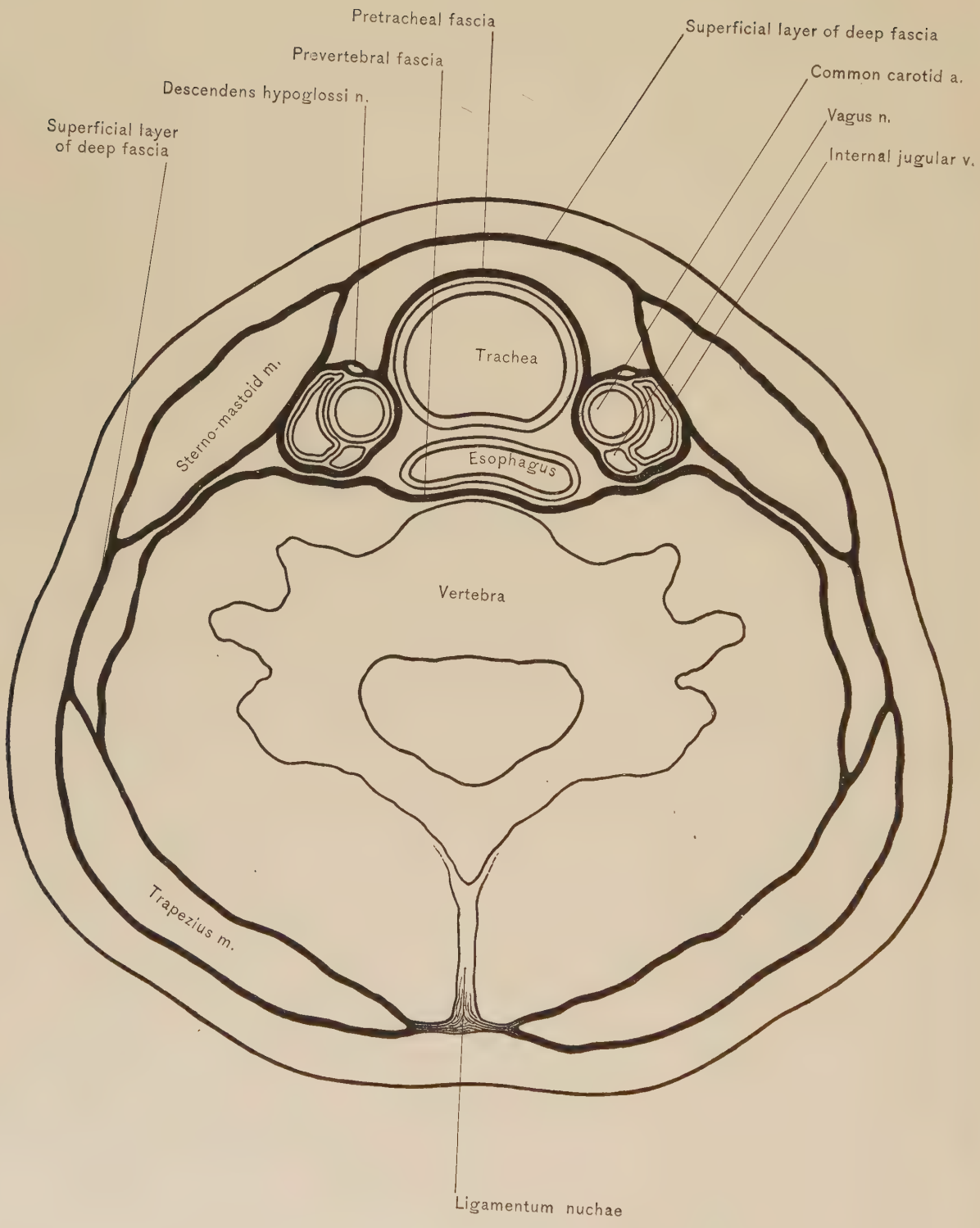


DIAGRAM OF DEEP CERVICAL FASCIA.

or *supraclavicular, branches* cross the middle of the clavicle, supply the integument over the supero-anterior part of the deltoid and the superior part of the pectoralis major muscle and the mammary gland, and communicate with the small cutaneous branches of the upper intercostal nerves; the posterior, or *supra-acromial, branches* cross the superior surface of the trapezius muscle and the acromion process, and supply the integument of the superior, lateral, and posterior parts of the shoulder. Herpetic eruptions (herpes cervico-occipitalis) occasionally develop in the area of distribution of the superficial branches of the cervical plexus. In caries of the cervical vertebræ pain may be referred to the areasof skin supplied by these nerves. It is through the descending branches of the cervical plexus that pain is referred to the neck in carcinoma of the mammary gland.

The **inframandibular (cervical) branch of the cervico-facial division of the facial nerve** emerges from the lower border of the parotid gland, and passes downward and forward under the platysma muscle, which it supplies, and communicates with the superficial cervical nerve. In the dissection of the neck for the removal of diseased glands the nerve may be so injured as to cause temporary dropping of the lower lip on the affected side.

The **deep cervical fascia (fascia colli)** (Plate CCXLIV), like the deep fascia in other portions of the body, consists of a superficial layer which surrounds the underlying muscles, vessels, and nerves, and of processes prolonged inward to form separate sheaths for the muscles and vessels, thus isolating, and helping to retain them in their proper positions. It varies in strength, being strongest below the angle of the mandible, above the clavicle, and in front of the trachea. In studying this fascia it will be found more satisfactory to trace it from behind, where it is attached to the ligamentum nuchæ, to the spinous process of the seventh cervical vertebra (vertebra prominens), and to the external occipital protuberance. At the ligamentum nuchæ the *superficial layer* immediately splits into two layers which inclose the trapezius muscle. From the anterior border of the trapezius it passes as a single layer across the posterior triangle of the neck to the posterior border of the sterno-mastoid muscle. This portion of the superficial layer is attached above to the mastoid process of the temporal bone and the superior curved (*superior nuchal*) line of the occipital bone, and below to the spine of the scapula, the acromion, and the clavicle. It is pierced by the external jugular vein directly above the clavicle, behind the clavicular origin of the sterno-mastoid muscle. At the posterior border of the sterno-mastoid, it is again continued as a single layer across the anterior triangle of the neck to the mid-line, where it joins the corresponding layer of fascia of the opposite side.

This portion of the superficial layer is attached above to the styloid process of the temporal bone and the lower border of the mandible, and in front, to the hyoid bone. Near the upper border of the sternum this layer of fascia divides into an anterior and a posterior layer, which are attached to the anterior and posterior margins, respectively, of the upper border of the sternum. Between these two layers is the **suprasternal intra-aponeurotic space,** the space of Burns. This space contains some fat, the sternal head of the sterno-mastoid muscle, the anterior jugular veins and the transverse branch connecting them, and sometimes one or two small lymph glands. The layer of fascia overlying the sterno-mastoid muscle is continued upon the face, over the parotid gland and the masseter muscle, as the parotideo-masseteric fascia, which is attached to the lower border of the zygomatic arch.

The portion of the superficial layer covering the trapezius and the sterno-mastoid muscles is so thin that their fibers can be seen through the fascia. At the angle of the mandible this layer of fascia sends a process inward, the **stylo-mandibular ligament,** which is attached to the styloid process. The superficial layer separates the partoid from the submaxillary (*submandibular*) gland. From this layer two processes are given off, a posterior and an anterior. The *posterior process,* or *prevertebral fascia,* arises at the anterior border of the trapezius muscle, and covers the splenius, the levator anguli scapulæ (*levator scapulæ*), the scaleni, and the prevertebral muscles: the subclavian, vertebral, inferior thyroid, supra-scapular (*transverse scapular*), and transverse cervical vessels, the cervical trunks of the brachial plexus, the phrenic nerve, and the cervical sympathetic nerves. The prevertebral fascia passes behind the great vessels, the vagus nerve, the pharynx, and the esophagus to be attached to the base of the skull, passing in front of the bodies of the cervical vertebræ to be attached below to the first rib, as far forward as the anterior margin of the scalenus anterior muscle. In the mid-line it passes behind the esophagus into the thorax. At the sides of the neck it assists in forming the posterior sheath of the carotid vessels. In its upper part toward the mid-line, it is separated from the bucco-pharyngeal fascia by loose areolar tissue. To the medial side of the scalenus anterior muscle it passes downward into the chest over the longus colli muscle and the bodies of the vertebræ. To the lateral side of the scalenus anterior muscle it splits to envelop the subclavian vessels, which it accompanies into the axilla, where, with a process from the costo-coracoid membrane, it forms the sheath of the axillary vessels. The *anterior process,* or *pretracheal fascia,* arises from the superficial layer near the anterior border of the sterno-mastoid muscle, passes beneath the sterno-hyoid and sterno-thyroid muscles, and in front of the trachea, splitting to envelop the thyroid gland. It is attached to the first rib, to which it binds the

tendon of the omo-hyoid muscle. This, with the posterior process just described and the layer of deep fascia beneath the sterno-mastoid muscle, completes the formation of the carotid sheath. The portion of the deep cervical fascia which envelops the trachea and the great vessels extends downward along the great vessels into the chest, where it is continuous with the fibrous layer of the pericardium. (Plate CCXLI.)

The close adherence of the fascia to the vessels of the neck hinders vascular contraction, favors hemorrhage, and increases the danger of air embolus in this region.

The superficial layer of the deep cervical fascia, with its two deep processes, divides the neck into three compartments: an anterior, a middle, and a posterior. (Plate CCXLII.) The *anterior compartment*, between the superficial layer and the pretracheal fascia, contains the anterior belly of the omo-hyoid, the sterno-hyoid, and the sterno-thyroid muscles. The *middle*, or *visceral, compartment*, between the pretracheal and prevertebral fasciæ, contains the thyroid gland, the trachea, and esophagus. The *posterior*, or *muscular, compartment*, between the prevertebral fascia and the superficial layer, contains the prevertebral muscles, the scaleni, the levator anguli scapulæ (*levator scapulæ*), and the muscles of the back of the neck, excepting the trapezius.

At the upper opening of the chest is a barrier formed by the attachment of the deep cervical fascia to the sternum, the first rib, and the clavicle, supporting the soft parts and preventing them from yielding to the pressure of the atmosphere during inspiration. The omo-hyoid muscle, when the hyoid bone is fixed, increases the tension of the pretracheal layer and assists in preventing atmospheric pressure from collapsing the walls of the blood vessels, especially the veins, and the apices of the lungs.

Suppuration.—In order to become familiar with the course of a suppurative process in the neck, a correct knowledge of the attachments of the deep cervical fascia is necessary. A collection of pus situated beneath the superficial layer of the deep fascia at the side of the neck may burrow into the axilla, and vice versa, one in the axilla may work its way into the neck; if situated beneath the layer of deep fascia, the posterior process, or the prevertebral fascia, covering the scaleni muscles, and attached to the first rib as far forward as the anterior border of the scalenus anterior muscle, it may burrow into the chest cavity, reaching the posterior mediastinum, or it may follow the sheath of the subclavian vessels into the axilla; if situated beneath the superficial layer of the deep facia in the anterior portion of the neck, it may enter the chest, finding its way into the superior mediastinum by way of the pretracheal fascia; if it lies beneath the anterior process, or pretracheal fascia, it may extend into the posterior mediastinum. Abscesses of

the neck frequently rupture into the esophagus or trachea, and even into the pleural sac or the great vessels at the side of the neck. Communication between abscesses and the deep vessels usually takes place beneath two of the strongest fasciæ in the body—the deep cervical and the fascia lata. Infection between the layers forming the carotid sheath may also cause a descending or ascending thrombosis. Prompt evacuation is therefore indicated in order to avoid the afore-mentioned serious possibilities.

Dissection.—The superficial layer of the deep fascia should be removed by making incisions similar to those made for the removal of the skin and the superficial fascia, being careful not to destroy the superficial branches of the cervical plexus of nerves which pierce it. The removal of the superficial layer will expose its two processes and other underlying structures.

The Cervical Plexus.—(Plate CCXLV.) Before taking up the description of the muslces of the neck and its dissection proper, the origins of the superficial branches of the cervical plexus of nerves should be observed. The cervical plexus is formed by the communication of the anterior divisions of the upper four cervical nerves, all of which communicate with the cervical sympathetic. It lies under the sterno-mastoid muscle, opposite the upper four cervical vertebræ, and rests upon the levator anguli scapulæ (*levator scapulæ*) and the scalenus medius muscles. Its branches consist of a superficial and a deep set. The *superficial branches*, already described, are the great auricular, the small (*lesser*) occipital, the superficial cervical, the suprasternal (*anterior supraclavicular*), the supraclavicular (*middle supraclavicular*), and the supra-acromial (*posterior supraclavicular*), all running to the skin and subcutaneous structures. They emerge at the side of the neck from beneath the posterior border of the sterno-mastoid muscle, at the level of the upper border of the thyroid cartilage. The *deep branches* are the phrenic, the communicating, and the muscular.

The **sterno-mastoid muscle** (Plate CCXLII), the largest muscle of the neck and its most important landmark, *arises* by two heads. The *medial*, or *sternal, head arises* from the upper part of the anterior surface of the sternum. The *lateral*, or *clavicular head*, broad, flattened, partly muscular and partly tendinous, *arises* from the medial third of the upper border and anterior surface of the clavicle. The two heads unite at a variable distance from the clavicle, and are *inserted* as one muscle by a strong, thick tendon into the lateral surface of the mastoid process of the temporal bone, and by a thin aponeurosis into the lateral two-thirds of the superior curved (*superior nuchal*) line of the occipital bone. The muscle is narrower in the middle than at either extremity. Its anterior border is the surgeon's guide in operations upon the anterior portion of the side of the neck, such as ligation of the common, external, and internal

PLATE CCXLV.

CERVICAL PLEXUS.

carotid arteries, the superior thyroid, lingual, facial (*external maxillary*), and occipital arteries at their origin, and the inferior thyroid artery as it enters the thyroid gland; exposing the spinal accessory (*accessory*) nerve; upon the left side in the operation of esophagotomy. The posterior border of the muscle is a guide in operations upon the posterior portion of the sides of the neck, such as ligation of the subclavian and vertebral arteries, or of the inferior thyroid artery at its origin; exposing the spinal accessory (*accessory*) nerve, the superficial branches of the cervical plexus, and the cervical trunks of the brachial plexus.

Blood Supply.—From the superior, middle, and inferior sterno-mastoid arteries. The superior sterno-mastoid is a branch of the occipital artery, and enters the muscle with the spinal accessory nerve; the middle sterno-mastoid is a branch of the superior thyroid artery, and enters the medial third of the muscle, after crossing the sheath of the common carotid artery in the superior carotid triangle on a level with the thyroid cartilage; the inferior sterno-mastoid is a branch of the suprascapular (*transverse scapular*) artery, and enters the lower third of the muscle. The muscle also receives a twig from the posterior auricular artery.

Nerve Supply.—From the spinal accessory (*accessory*) and the anterior divisions of the second and third cervical nerves.

Action.—The combined action of the sterno-mastoid muscles is to draw the head forward and at the same time elevate the chin; when one muscle acts alone, it turns the face to the opposite side, coöperating with the opposite splenius muscle; it also draws the head toward the shoulder of the same side. With the head fixed, these muscles raise the sternum, as in forced respiration.

Torticollis.—Permanent contraction of one of the sterno-mastoid muscles constitutes torticollis (wry-neck). The clavicular portion of the trapezius may be associated with the condition. The deep muscles of the neck, the splenius capitis, the splenius cervicis, the complexus (*semispinalis capitis*), superior oblique, inferior oblique, and rectus capitis posterior major, and the deep fascia of the neck may also be involved in this deformity, particularly in cases of long standing.

In true congenital wry-neck, probably due to faulty position of the fetus *in utero*, the sterno-mastoid muscle has, in some instances, been found to be abnormally short. Some cases of wry-neck are doubtless due to laceration of the muscle during birth, with subsequent cicatrical contraction. Facial asymmetry and deformities of the cervical portion of the spinal column may be associated with long-standing cases of torticollis. In spasmodic wry-neck the sterno-mastoid muscle is at fault, through the spinal accessory (*accessory*) nerve, though some of the muscles previously mentioned, as well as the trapezius muscle, may be involved; resection of the spinal accessory (*accessory*) and branches of the

posterior divisions of the cervical nerves has been performed in these cases. It should not be forgotten that irritation of some of the cervical nerves, as by inflamed lymph glands and caries of the cervical vertebræ, may cause a faulty position of the head which may be mistaken for torticollis due to other conditions.

THE TRIANGLES OF THE NECK (Plates CCXLVI; CCXLVII)

The sterno-mastoid muscle, owing to its oblique position, divides each half of the neck into an anterior and a posterior triangle. The **Anterior Triangle** is bounded above by the lower border of the body of the mandible and a line extending from its angle to the mastoid process of the temporal bone; anteriorly, by a line extending from the symphysis of the mandible to the middle of the suprasternal (*jugular*) notch, or by the median line of the neck, and posteriorly, by the anterior border of the sterno-mastoid muscle; its apex is below, at the sternum. This triangle is subdivided, by the posterior belly of the digastric muscle and the anterior belly of the omo-hyoid muscle, into three small triangles, which from above downward are: the *submaxillary*, or *digastric*, the *superior carotid*, or *arterial*, and the *inferior carotid*, or *muscular*, triangle. The **Posterior Triangle** is bounded anteriorly by the posterior border of the sterno-mastoid muscle; posteriorly, by the anterior border of the trapezius muscle, and inferiorly, by the clavicle; its apex is at the occipital bone just posterior to the mastoid. This triangle is subdivided, by the posterior belly of the omo-hyoid muscle, into two smaller triangles, the upper, the larger of the two, being known as the *occipital*, and the lower, as the *subclavian* triangle.

Attention is called to the fact that the boundaries of these triangles by muscular margins do not harmonize with the enumeration of their contents, many of which are overlapped by the boundary muscles, particularly the sterno-mastoid, and are, therefore, really outside the spaces to which they are thus inaccurately accredited. The most accurate dividing line between the anterior and posterior triangles would be the mid-line of the sterno-mastoid muscle rather than its two borders.

Dissection.—Having mapped out the triangles into which the side of the neck is divided, the dissection of the individual triangles should next be made, commencing with the occipital. After reflecting the superficial layer of the deep cervical fascia which forms the roof of the occipital triangle, the fat and areolar tissue occupying the triangle should be dissected out, thus exposing its contents and the posterior process of the deep cervical fascia which covers the muscles forming its floor.

The occipital triangle.—The occipital triangle, the upper and larger division of the posterior triangle, is bounded anteriorly by the sterno-mastoid; posteriorly,

PLATE CCXLVI.

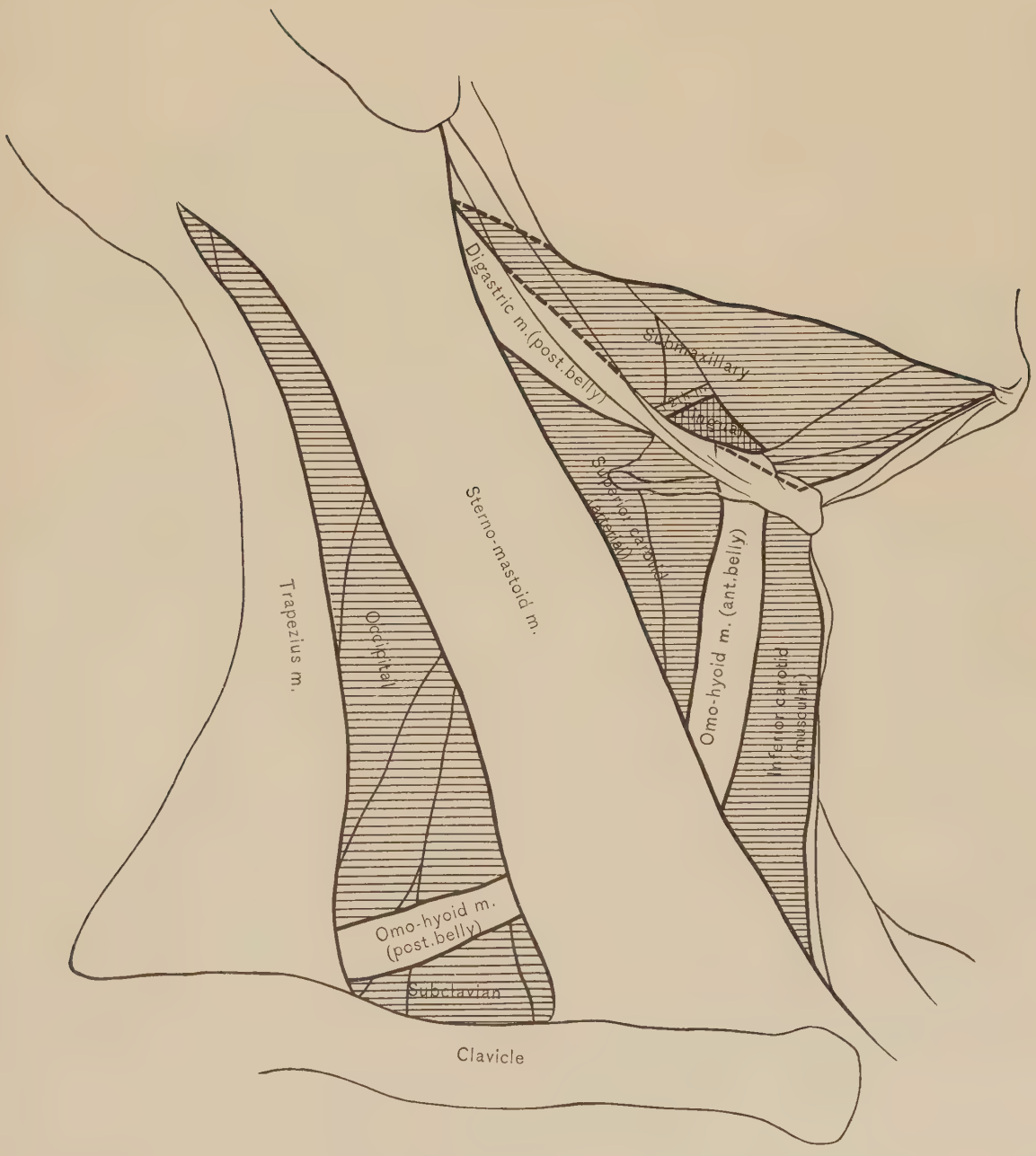
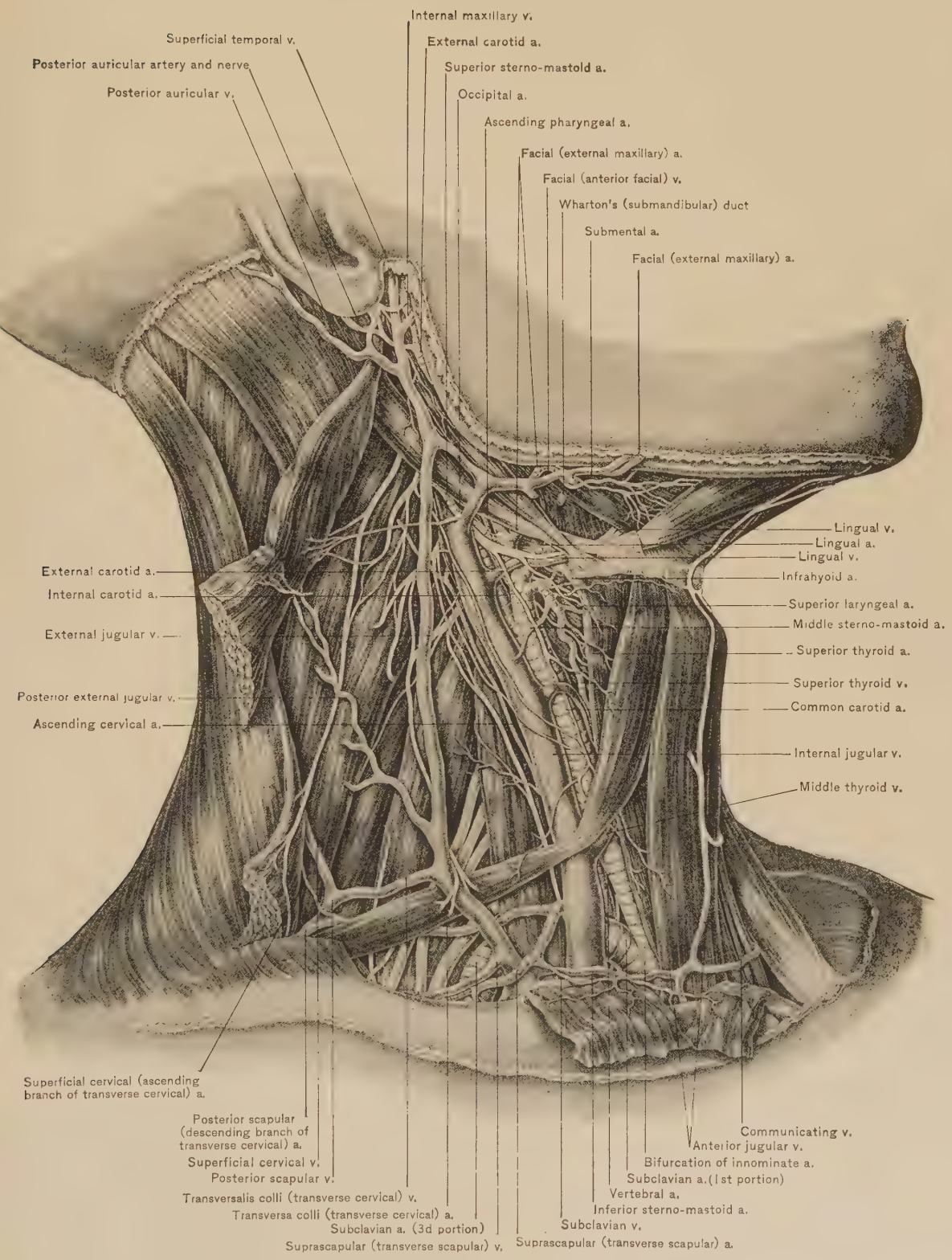


DIAGRAM OF TRIANGLES OF NECK.

PLATE CCXLVII.



VESSELS OF NECK.

by the trapezius; inferiorly, by the posterior belly of the omo-hyoid muscle. Its *roof* is formed by the superficial layer of the deep cervical fascia, covered by the platysma muscle, superficial fascia, and skin. When the sterno-mastoid and trapezius muscles do not meet at the apex of the triangle, a small portion of the occipital artery may be seen in the interval between the splenius and the trapezius muscles. Crossing the triangle obliquely downward and backward from beneath the sterno-mastoid muscle are the spinal accessory (*accessory*) nerve and the branches of the third and fourth cervical nerves, which enter and supply the lower part of the trapezius muscle. Emerging from beneath the posterior border of the sterno-mastoid muscle are the superficial branches of the cervical plexus of nerves, which leave the triangle by piercing its roof. Occasionally, the middle sterno-mastoid artery terminates in this triangle. Running along the posterior border of the sterno-mastoid muscle is the *postcervical chain of lymph glands.* These glands are of special importance in the diagnosis of early secondary syphilis. A chain of glands is also found along the anterior border of the trapezius. Crossing the lower part of the triangle is the transverse cervical artery and its companion vein. The superficial cervical (*ascending branch of transverse cervical*) artery, one of the terminal branches of the transverse cervical, usually occupies the postero-inferior angle of this space; it runs upward, parallel with the anterior border of the trapezius muscle, but is sometimes concealed by this border. At the antero-inferior angle of the triangle the upper part of the brachial plexus may be seen. Branches of the third and fourth cervical nerves cross the floor of the triangle to supply the levator anguli scapulæ (*levator scapulæ*) muscle.

The muscles forming the *floor* of the occipital triangle are, from above downward: the splenius capitis, the levator anguli scapulæ (*levator scapulæ*), the scalenus medius, and the scalenus posterior, which cannot be seen, however, until the posterior process of the deep cervical fascia is removed. The most important superficial structure in the occipital triangle is the spinal accessory (*accessory*) nerve. It is frequently injured in block dissections of the neck, resulting in shoulder-drop on the affected side.

The **spinal accessory** (**accessory**) **nerve** (Plate CCXLIII), the eleventh cranial nerve, consists of an *accessory* portion, from the medulla oblongata, and a *spinal* portion, from the cervical portion of the spinal cord as low as the sixth or seventh cervical nerve. The spinal portion passes upward through the spinal canal between the ligamentum denticulatum and the posterior roots of the spinal nerves, and enters the cranial cavity through the foramen magnum to join the accessory portion. The two portions emerge together from the cranial cavity through the jugular foramen, just lateral to which the accessory portion joins the ganglion of the root of the vagus nerve. The spinal portion then passes successively

behind the internal jugular vein, the posterior belly of the digastric, and the stylo-hyoid muscle, to enter the upper part of the sterno-mastoid muscle, entering its under surface midway between its two borders and two and a half centimeters (one inch) below the tip of the mastoid process. It leaves the muscle at the middle of the posterior border. Within the sterno-mastoid muscle it is joined by a branch of the second cervical nerve to form the *sterno-mastoid plexus*, and under the border of the trapezius it communicates with the third and fourth cervical nerves, forming the *subtrapezial plexus*. The superior sterno-mastoid artery accompanies the nerve into the muscle, which it supplies. After piercing the sterno-mastoid muscle, it crosses the occipital triangle obliquely downward and backward to enter and supply the trapezius muscle.

Resection of a portion of the spinal accessory (*accessory*) nerve may be performed for the relief of spasmodic torticollis. The nerve may be exposed at one of three points: just before it enters the sterno-mastoid muscle or in the substance of the muscle or at the posterior border of the muscle. Of these methods, the first is the best. To expose the nerve before it enters the muscle, the head and neck should be well extended, and an incision made along the anterior border of the upper third of the muscle, dividing the skin, superficial fascia, some fibers of the platysma muscle, and the superficial layer of the deep fascia, avoiding, if possible, the external jugular vein. Displace the sterno-mastoid muscle laterally, when the nerve will be found beneath the prevertebral fascia and passing from beneath the sheath of the internal jugular vein, to enter the muscle about two and a half centimeters (one inch) below the tip of the mastoid process. The prominent transverse process of the atlas lies above the nerve, and serves as a deep guide in locating it.

To expose the nerve in the substance of the sterno-mastoid muscle an incision should be made in the mid-line of the muscle. The muscle fibers are separated and the nerve exposed as it passes through the deeper portion just above the level of the thyroid cartilage. The skin, superficial fascia, fibers of the platysma muscle, superficial layer of the deep fascia, the sterno-mastoid muscle, and the superior and middle sterno-mastoid arteries will be cut. The external jugular vein should, if possible, be avoided.

To expose the nerve along the posterior border of the muscle carry an incision along the intermediate third of that border. This will divide the skin, superficial fascia, fibers of the platysma muscle, and the superficial layer of the deep fascia. The small (*lesser*) occipital nerve will be seen running upward along the posterior border of the sterno-mastoid muscle. Trace this nerve downward, and locate the spinal accessory (*accessory*) nerve as it emerges from the posterior border of the sterno-mastoid on a level with the upper border of the thyroid cartilage.

The **middle sterno-mastoid artery** is often large and extends well into, if not across the occipital triangle, supplying its lymph glands and connective tissue. On opening an abscess in this triangle, if more than the usual amount of bleeding follows, the probability is that an anomalously large middle sterno-mastoid artery has been severed. In these circumstances the incision should be enlarged so as to expose both ends of the bleeding vessel and permit their ligation. This accident, by misleading the surgeon to believe that only a small, subcutaneous vessel has been divided, and thus rely on a compress to control the bleeding, may result in death from hemorrhage. Autopsy will reveal a severed, large middle sterno-mastoid artery.

The **transverse cervical artery** terminates in the lower part of the occipital triangle, by dividing into the superficial cervical (*ascending branch of transverse cervical*) and the posterior scapular (*descending branch of transverse cervical*) arteries. The *superficial cervical* (*ascending branch of transverse cervical*) *artery* has been traced to the anterior border of the trapezius muscle, beneath which it anastomoses with the superficial branch of the princeps cervicis (*descending branch of the occipital*) artery. The *posterior scapular* (*descending branch of transverse cervical*), occasionally a branch of the third part of the subclavian artery, passes beneath the levator anguli scapulæ (*levator scapuli*) muscle, then along the vertebral border of the scapula, running between the insertions of the serratus magnus (*serratus anterior*) and the rhomboidei muscles to the inferior angle of the scapula, where it anastomoses with the subscapular artery. In its course it gives off branches to the adjacent muscles and anastomoses with the suprascapular (*transverse scapular*) and dorsalis scapulæ (*circumflex scapular*) arteries. Occasionally, the transverse cervical is the only branch which arises from the third portion of the subclavian, and in this case the superficial cervical (*ascending branch*) originates from the thyroid axis.

The anastomoses between the transverse cervical and the suprascapular (*transverse scapular*) and the subscapular arteries from the axillary are of considerable importance after ligation of the terminal subclavian.

The **subclavian, or supraclavicular, triangle,** the smaller of the two divisions of the posterior triangle, is one of the most important triangles of the neck. It is bounded anteriorly by the posterior border of the sterno-mastoid muscle; superiorly, by the posterior belly of the omo-hyoid muscle, and inferiorly, by the clavicle. The *base* of the triangle is formed by the posterior border of the sterno-mastoid muscle, and is directed forward. Its *roof* is formed by the superficial layer of the deep fascia, covered by the platysma muscle, superficial fascia, and skin. The depth of this space is increased when the shoulder is raised and diminished when it is depressed. In all operations in this triangle, therefore, the

shoulder should be depressed, thus bringing the contents of the triangle nearer to the surface. Its size depends on the extent of the attachment of the trapezius and sterno-mastoid muscles to the clavicle, and on the position of the omo-hyoid muscle.

Dissection.—In removing the superficial layer of the deep fascia, reflecting the roof of the triangle exposes some lymph glands, loose areolar tissue, and fat, and a small portion of the external jugular vein; also the termination of the transverse cervical and suprascapular (*transverse scapular*) veins, the jugulo-cephalic vein, when present, and some additional veins from the muscles, the layer of deep fascia (posterior process) covering the deeper structures namely, the scaleni muscles, the phrenic nerve, the cervical trunks of the brachial plexus of nerves, and the subclavian, suprascapular (*transverse scapular*), and transverse cervical vessels will be seen. Remove the posterior process of the deep fascia from the triangle and study these deeper structures.

Contents of the Subclavian Triangle.—Crossing the lower part of the triangle beneath the clavicle are the *suprascapular* (*transverse scapular*) *artery* and *vein;* these vessels pass in front of the third portion of the subclavian artery (the point of election), and may be the source of severe hemorrhage if divided when ligating the artery. The relation of the suprascapular (*transverse scapular*) to the subclavian artery at its point of election is the same as that held by the middle sterno-mastoid artery to the common carotid artery at its point of election. Crossing the upper angle of the triangle are the *transverse cervical artery* and *vein.* Entering the triangle behind the posterior border of the lower part of the sterno-mastoid muscle is the *external jugular vein,* which passes in front of the subclavian artery to reach the subclavian vein. The external jugular vein is here joined by the suprascapular (*transverse scapular*) and transverse cervical veins, and at times by a small branch, the jugulo-cephalic, which passes over the clavicle, connecting the cephalic with the external jugular vein. Sometimes the suprascapular (*transverse scapular*), transverse cervical, jugulo-cephalic, posterior external jugular, and some smaller veins form a plexus in front of the subclavian artery, which, especially when distended, renders operations in this space difficult. Emerging from beneath the posterior border of the sterno-mastoid and scalenus anterior muscles is the third portion of the *subclavian artery,* which crosses the triangle obliquely downward and lateralward. The artery passes posterior to the scalenus anterior muscle, while the vein passes anterior to the muscle and on a slightly lower plane. The *right subclavian artery* arises from the innominate artery behind the sterno-clavicular articulation and ascends lateralward to the medial margin of the scalenus anterior. The *left subclavian artery* arises from the arch of the aorta and is much deeper in the thorax than the right; it ascends

almost vertically and arches anterolaterally to reach the medial border of the scalenus anterior. Normally, the third part of the subclavian artery does not give off any branches; the posterior scapular (*descending branch of the transverse cervical*), however, one of the terminal branches of the transverse cervical artery, often arises from this portion of the vessel; the transverse cervical artery itself also may arise from the third portion of the subclavian artery. Passing downward over the scalenus anterior muscle, beneath the posterior process of the deep fascia, is the *phrenic nerve*, which enters the chest through its superior opening, and between the subclavian artery and vein. It is here that phrenicotomy can be done. Running through the superolateral part of the triangle, above and lateral to the subclavian artery, are the three cervical trunks of the *brachial plexus* of nerves, which emerge at the side of the neck from between the scalenus anterior and scalenus medius muscles. Ligation of the subclavian, though not frequent, is sometimes necessary. The third portion is the point of election. Aneurysm is more frequent on the right side than on the left, the third portion being most frequently involved. Digital compression can be exercised just above, and slightly lateral to the center of the clavicle. When ligating the third portion of the subclavian artery, the upper trunk of the plexus may be mistaken for the artery, and the ligature passed around it. This trunk is, therefore, a very useful guide in locating the artery, and should always be kept in mind. A few lymph glands, which are continuous with the axillary lymphatics, are found in this space. These glands should always be removed in the radical operation for carcinoma of the mammary gland. The triangle is also crossed by the suprascapular and posterior thoracic (*long thoracic*) nerves and the nerve to the subclavius muscle.

The *floor of the triangle* is formed by the scalenus medius and scalenus posterior muscles, the first rib, and the upper digitation of the serratus magnus (*serratus anterior*) muscle.

The inferior carotid (muscular) triangle is bounded in front by the median line of the neck; behind, by the anterior border of the sterno-mastoid, and above, by the anterior belly of the omo-hyoid muscle. The *roof* is formed by the skin, the superficial fascia, which contains the platysma muscle and the descending branch of the superficial cervical (*cutaneous colli*) nerve, and by the superficial layer of the deep fascia. The lateral margins of the sterno-hyoid and the sterno-thyroid, and the anterior margin of the sterno-mastoid muscle cover the more important contents of the triangle, and should be drawn aside before dissecting the deeper structures.

The Contents of the Inferior Carotid (Muscular) Triangle comprise the common carotid artery (not strictly in the triangle, as the vessels lie under the margin of the sterno-mastoid muscle, but so closely related to the contents of the

triangle that mention of it here is proper), the internal jugular vein, and the vagus nerve, all three being inclosed in a common sheath, in front of which are filaments of nerves derived from the loop of communication between the descendens hypoglossi, a branch of the hypoglossal, and the communicantes hypoglossi (*descendens cervicalis*) nerves, which are deep branches of the cervical plexus; behind the sheath of the vessels are the cervical sympathetic and its cardiac branches. Upon the medial side of the sheath of the vessels are the lateral lobe of the thyroid gland, the trachea, the larynx, the esophagus, the inferior, or recurrent, laryngeal nerve (motor nerve of the larynx), which occupies the groove between the trachea and the esophagus, and the terminal portion of the deep chain of cervical lymph glands. To the lateral side of the sheath of the vessels, running over the scalenus anterior muscle, is the phrenic nerve. The inferior thyroid artery, a branch of the thyroid axis, passes upward and medialward through this space to the lateral side of, and then behind the sheath of the vessels. Situated deep in the interval beneath the longus colli and the scalenus anterior muscles, and behind the sheath of the vessels, are the vertebral artery and its accompanying vein. In this triangle the relation between the internal jugular vein and the common carotid artery differs upon the two sides of the neck: upon the right side the vein is slightly lateral to the artery, the two vessels being in the lower part of the triangle, separated by a narrow interval, while on the left side it lies closer to the artery and somewhat overlaps it.

The *floor of the triangle* is formed by the longus colli and scalenus anterior muscles.

The superior carotid, or carotid, triangle, the triangle of election, is bounded superiorly by the posterior belly of the digastric muscle; posteriorly, by the anterior border of the sterno-mastoid muscle, and inferiorly, by the anterior belly of the omohyoid muscle; its apex is directed toward the median line of the neck. Its *roof* is formed by the skin, the superficial fascia, the platysma muscle, and the superficial layer of the deep fascia.

The Contents of the Superior Carotid Triangle are: the common carotid artery and its terminal divisions, the external and the internal carotid arteries the internal jugular vein, and the vagus nerve; these are all inclosed in a common sheath, the vein lying lateral to the artery and the nerve between, and on a plane posterior to both, resembling the ramrod in a double-barreled gun. The common carotid artery usually divides into the external and internal carotid arteries on a level with the upper border of the thyroid cartilage; division may, however, take place below or above this point. In this triangle the external carotid artery gives off the *superior thyroid, lingual, facial, occipital,* and the *ascending pharyngeal arteries,* all of which, excepting the occipital, are accom-

panied by their corresponding veins on their way to empty into the internal jugular vein. Passing downward in front of the carotid sheath is the *descendens hypoglossi nerve*, and behind the sheath, the *cervical sympathetic*. To the lateral side of the sheath, above, is the *spinal accessory* (*accessory*) *nerve*, which pierces the sterno-mastoid muscle; to the medial side of the sheath is the *superior laryngeal nerve*, a branch of the vagus, accompanied by the *superior artery*, a branch of the superior thyroid artery. Both the superior laryngeal artery and the internal laryngeal branch of the superior laryngeal nerve enter the larynx through the thyro-hyoid membrane. To the medial side of the sheath of the vessels, and a little lower, the *superior thyroid artery* and the *external laryngeal nerve*, a branch of the superior laryngeal nerve, are seen passing beneath the sterno-thyroid muscle. The *hypoglossal nerve* is seen in the upper part of the triangle, curving around the occipital artery at its origin from the external carotid, and crossing over the external and internal carotid arteries. Upon the medial side of the triangle are the upper part of the larynx and the lower portion of the pharynx. In the deep part of the triangle, to the medial side of the sheath of the vessels, are seen the pharynx, the esophagus, and the deep chain of cervical lymph glands, the terminal portion of which was seen when dissecting the inferior carotid (*muscular*) triangle. The superior carotid is the *triangle of election* for the ligation of the common carotid artery, the artery being more superficial and accessible at this part. Crossing the sheath of the vessels in this triangle is the middle sterno-mastoid, a small branch of the superior thyroid artery, which is severed in the ligation of the common carotid artery in this triangle.

The *floor of the triangle* is formed by the thyro-hyoid, the hyoglossus, and the middle and inferior constrictor muscles of the pharynx.

The **submaxillary, or digastric, triangle**, the uppermost of the three anterior triangles, is bounded superiorly by the lower border of the body of the mandible, and a line drawn from the angle of the mandible to the mastoid process of the temporal bone; inferiorly, by the posterior belly of the digastric and the stylo-hyoid muscles, and the line of these muscles extended to the median line of the neck, and anteriorly, by the median line of the neck. Its *roof* is formed by the skin, the superficial fascia, the platysma muscle, and the superficial layer of the deep cervical fascia which in this region is exceptionally well developed.

Contents of the Submaxillary (Submandibular), or Digastric, Triangle.—The stylo-maxillary (*stylo-mandibular*) ligament, a process of the deep cervical fascia which extends from the styloid process of the temporal bone to the angle of the mandible and separates the submaxillary (*submandibular*) and parotid salivary glands, divides the submaxillary, or digastric, triangle into an anterior and a posterior portion. The *posterior portion* contains a part of the

external carotid artery, embedded in the substance of the parotid gland, the internal jugular vein, the vagus, glosso-pharyngeal, hypoglossal, and cervical sympathetic nerves, the origins of the stylo-glossus and stylo-pharyngeus muscles, and the stylo-hyoid ligament. The last three of these structures, with the glosso-pharyngeal nerve, pass into the anterior part of the triangle between the internal and external carotid arteries. In addition to the terminal portion of the stylo-pharyngeus and stylo-glossus muscles, the anterior portion contains the stylo-hyoid ligament and the glosso-pharyngeal nerve, which pass from the posterior portion, the submaxillary (*submandibular*) gland, the facial (*external maxillary*) artery and facial (*anterior facial*) vein, the ascending palatine, tonsillar, submaxillary (*glandular*), and submental branches of the facial (*external maxillary*) artery, all of which arise within the triangle, the hypoglossal nerve, the mylo-hyoid nerve, the mylo-hyoid artery, and lymph glands. A chain of lymph glands, ten to fifteen in number, is found below the body of the mandible. These glands belong to the superficial cervical lymphatics, and are known as the *submaxillary (submandibular) lymph glands.* In malignant growths of the lip, the mandible, the tongue, or the oral and pharyngeal mucous membrane, this chain of glands becomes infected, and should always be removed, whether enlarged or not. In the operation for the removal of a malignant growth involving the areas which these glands drain, first remove the submaxillary (*submandibular*) lymph glands of both sides of the neck, because of the decussation of their radicals, and in some instances, the submaxillary (*submandibular*) salivary gland, and then remove the growth. Tuberculosis of these glands is not uncommon, because of the large area from which they receive lymph; infection from inflammatory affections of the pharyngeal, nasal, and oral mucous membranes, as well as from carious teeth, is very frequently the cause of disease of these glands. An extensive cervical cellulitis, known as *Ludwig's angina,* may originate from septic processes in the mouth and later affect the submaxillary (*submandibular*) lymph glands.

The *floor of the submaxillary (submandibular) triangle* is formed by the mylo-hyoid muscle, the hyoglossus, the superior constrictor, and a small portion of the middle constrictor muscles of the pharynx.

Dissection.—Reflect the roof of the triangle by removing the superficial layer of the deep cervical fascia, and expose the submaxillary (*submandibular*) salivary gland, with the exception of its upper portion, which is hidden by the body of the mandible. The gland is surrounded by a fibrous capsule, which is derived from the superficial layer of the deep fascia. Displace the submaxillary (*submandibular*) gland upward upon the face, holding it there with hooks while further dissection of the triangle is made. In displacing the gland avoid severing the facial (*anterior facial*) vein, which passes over it, and the facial (*external maxillary*) artery, which passes through the groove on its deep surfaces.

The lingual, or Lesser's, triangle.—The portion of the submaxillary (*submandibular*), triangle, through which the lingual artery runs, is frequently spoken of as the lingual triangle. In relation with this triangle are the submaxillary (*submandibular*) gland, the anterior and posterior belly and the tendon of the digastric muscle, the hypoglossal nerve, the hyoglossus muscle, and the middle constrictor muscle of the pharynx. This subdivision of the submaxillary triangle is bounded superiorly by the hypoglossal nerve, posteriorly by the posterior belly of the digastric muscle, and anteriorly by the anterior belly of the digastric and the mylo-hyoid muscle; its *roof* is formed by the submaxillary (*submandibular*) gland, and its *floor* by the hyoglossus and the middle constrictor muscle of the pharynx. In ligating the lingual artery an incision is carried above and parallel with the greater cornu of the hyoid bone; the skin, the superficial fascia, the platysma muscle, and the superficial layer of the deep fascia are divided, and the submaxillary (*submandibular*) gland is exposed. Lift the gland upward, and note the artery beneath the hyoglossus muscle and beneath the interval between the hypoglossal nerve and the tendon of the digastric muscle. If the attachment of the digastric central tendon is long, the hypoglossal nerve may be below the muscle, so that in reality no lingual triangle is present, the artery being found closer to the hyoid bone than the central tendon. In making the incision through the hyoglossus muscle be careful to avoid wounding the middle constrictor muscle, division of which would open the pharynx. It is not necessary to cut the hyoglossus, as the artery is readily secured before it passes beneath that muscle, without endangering the pharynx. It is much simpler to ligate the lingual artery at its origin from the external carotid.

Dissection.—Divide the sterno-mastoid muscle at about its middle, and reflect the two portions. This exposes the descendens hypoglossi nerve, which lies upon the sheath of the vessels, the communicantes hypoglossi (*descendens cervicalis*) nerves, the ansa hypoglossi, the tendon of the omo-hyoid muscle, the sheath of the vessels, the spinal accessory (*accessory*) and phrenic nerves, the cervical plexus, the scalenus anterior muscle, and part of the subclavian vessels and some of their branches. The spinal accessory (*accessory*) and phrenic nerves, the cervical plexus, the scalenus anterior muscle, and the subclavian vessels are covered by the posterior portion of the two processes of the deep cervical fascia, the prevertebral, overlaid by some areolar and fatty tissue. Remove the fat and areolar tissue with the prevertebral layer of fascia covering the structures just named: the inferior thyroid, the vertebral suprascapular (*transverse scapular*), transverse cervical, and vertebral arteries.

THE CERVICAL PLEXUS OF NERVES (Plate CCXLV)

The cervical plexus is formed by the anterior primary divisions of the upper four cervical nerves. These constitute the roots of the plexus. It is

situated in the upper part of the neck, beneath the sterno-mastoid muscle, and rests upon the scalenus medius and levator anguli scapulæ (*levator scapulæ*) muscles. It differs from the brachial plexus in forming a network rather than a bundle of cords. In other words, it is a looped plexus, consisting of three loops. Each nerve, excepting the first, divides into an ascending and a descending branch, which, uniting with similar parts of the contiguous nerves, form the plexus. The branches of the plexus are divided into a superficial and a deep set. The *superficial set* has been described with the superficial fascia of the neck. The *deep set* is for convenience divided into an internal and an external series. The *internal series* includes the phrenic, the communicantes hypoglossi (*descendens cervicalis*), and muscular and communicating branches; the *external series* includes muscular and communicating branches.

The **phrenic nerve,** the internal respiratory nerve of Bell, supplies the diaphragm. It is chiefly a motor nerve but contains some sensory branches. It arises from the third and fourth cervical nerves, and receives a communicating branch from the fifth. It passes downward and medialward over the anterior surface of the scalenius anterior muscle, beneath the omo-hyoid muscle, the transverse cervical and suprascapular (*transverse scapular*) arteries, and the thoracic duct (left side), and enters the superior opening of the chest behind the subclavian vein and in front of the subclavian artery. It then crosses in front of the internal mammary artery and the root of the lung, and passes through the middle mediastinum between the mediastinal layer of the pleura and the pericardium, to reach the diaphragm, which it pierces for final distribution upon its lower surface. At the base of the neck it is joined by a filament of the sympathetic, and sometimes by a branch from the nerve to the subclavius muscle. In the chest it is accompanied by the arteria comes nervi phrenici (*pericardiaco-phrenic*), a branch of the internal mammary artery. The origin of the phrenic nerve is mainly from the fourth cervical segment of the spinal cord, which is situated behind the upper part of the body of the fourth cervical vertebra. The fact that this nerve is the one which innervates the diaphragm, explains the fatal results of injury to the spinal cord by fractures and dislocations of the upper cervical vertebræ.

The **right phrenic nerve** is situated somewhat deeper, and runs in a more vertical direction than the left; it lies lateral to the right innominate vein and the superior vena cava. The **left phrenic nerve** is longer than the right because of its winding around the left side of the heart in order to reach the diaphragm, which is lower on the left side than on the right. In the neck it crosses the subclavian artery, enters the thorax between the left subclavian and carotid arteries, and crosses the cervical sympathetic and the arch of the aorta.

The **communicantes hypoglossi** (**descendens cervicalis**) arise from the second and third cervical nerves, pass downward to the lateral side of the internal jugular vein, then cross in front of the vein, and join the *descendens hypoglossi*, an apparent branch of the hypoglossal nerve, in front of the sheath of the blood vessels, forming the loop known as the *ansa hypoglossi*. The descendens hypoglossi has its origin from the anterior division of the first cervical nerve and joins the hypoglossal just after its emergence from the skull. The descendens hypoglossi, communicantes hypoglossi (*descendens cervicalis*) and the ansa (*cervical loop*) supply the depressor muscles of the hyoid bone and the larynx namely, the sterno-hyoid, sterno-thyroid, and both bellies of the omo-hyoid, together with the genio-hyoid and thyro-hyoid muscles. The loop, or ansa, lies behind the internal jugular vein, and within or outside of the sheath of the vessels.

The **muscular branches** of the internal series arise from the first, second, third, and fourth cervical nerves; they supply the rectus capitis anterior major (*longus capitis*), rectus capitis anterior minor (*rectus capitis anterior*), rectus capitis lateralis, and longus colli muscles.

The **communicating branches** of the internal series connect the cervical plexus with the cervical sympathetic, vagus, and hypoglossal nerves.

The **muscular branches** of the external series supply the sterno-mastoid, the trapezius, the levator anguli scapulæ (*levator scapulæ*), and the scalenus medius muscles; the branch to the sterno-mastoid arises from the second cervical nerve; the branches to the levator anguli scapulæ (*levator scapulæ*), trapezius, and scalenus medius arise from the third and fourth cervical nerves.

The **communicating branches** of the external series connect the cervical plexus with the spinal accessory (*accessory*) nerve in the sterno-mastoid muscle, in the occipital triangle, and also beneath the trapezius muscle, forming the **subtrapezial plexus.**

Pain in one or more of the areas supplied by the various sensory branches of the cervical nerves may be caused by caries of the cervical vertebræ. Irritation of these nerves produces pain or spasm of the muscles in the regions supplied by the posterior branches of the nerves, as well as in those supplied by the cervical and brachial plexuses.

Examine the carotid sheath and the structures in relation with it.

The **Carotid Sheath** (Plate CCXLIV) is formed by the division of the superficial layer of the deep cervical fascia which passes beneath the sterno-mastoid

muscle, by the prevertebral and pretracheal fasciæ. It is divided by septa into three compartments: the medial one contains the common carotid artery, the lateral, the internal jugular vein, and the posterior one, the vagus nerve.

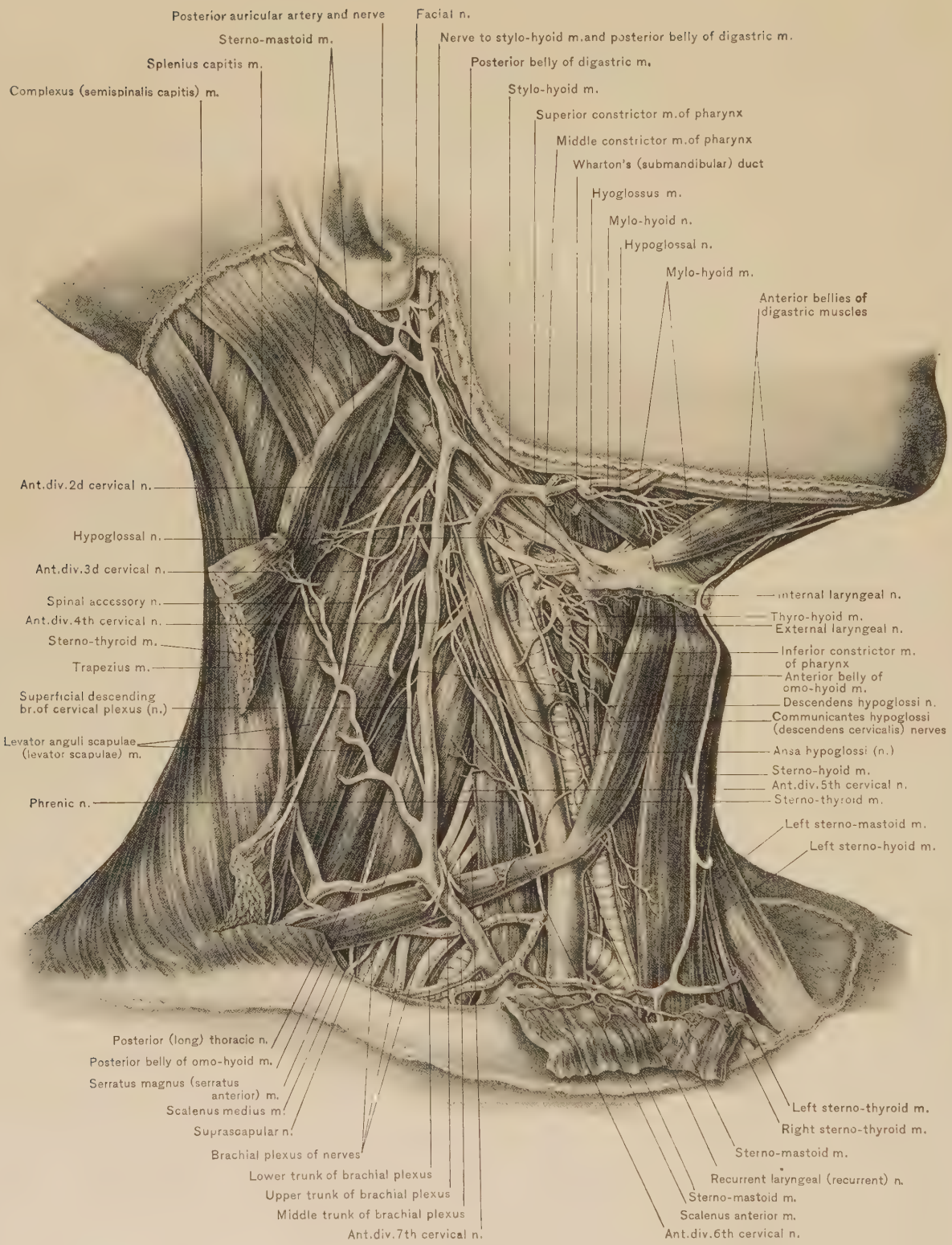
The **descendens hypoglossi nerve,** sometimes called the descendens noni, is usually seen lying in front of the carotid sheath, but occasionally it lies within the anterior wall of the sheath. It is given off from the hypoglossal nerve, which it accompanies from the upper portion of the neck, as the latter winds around the occipital artery. It is, however, not a true branch of the hypoglossal nerve, its fibers originally arising from the anterior division of the first cervical nerve and running with the trunk of the hypoglossal nerve for a short distance.

Lymph glands.—A deep chain of lymph glands, ten to sixteen in number, is in relation with the lateral wall of the sheath of the vessels, and extends from the mastoid tip to the point where the omo-hyoid crosses the vessels. These glands, communicating with the superficial chain, are more or less involved in enlargement of the latter. Every surgeon, experienced in the removal of glandular tumors of the neck, appreciates this fact when forced to carry the dissection to the extent of exposing the carotid sheath for some distance, in order to remove all the enlarged glands. Where it is not possible to make a good exposure and dissect with safety around the vessels by simply displacing the sterno-mastoid muscle, it will be necessary to divide the muscle. In making a difficult dissection in a region rich in important structures success is obtained only by having a good exposure, which necessitates a large wound. Frequent release of tension on the mass during the dissection is necessary, in order to allow the jugular vein to fill up and stand out.

Dissection.—Remove the deep chain of lymph glands together with the fat and connective tissue around them, and lay open the sheath; this exposes the carotid artery, the internal jugular vein, lying lateral to the common carotid artery, and the vagus nerve, between the vein and artery in a plane posterior to both.

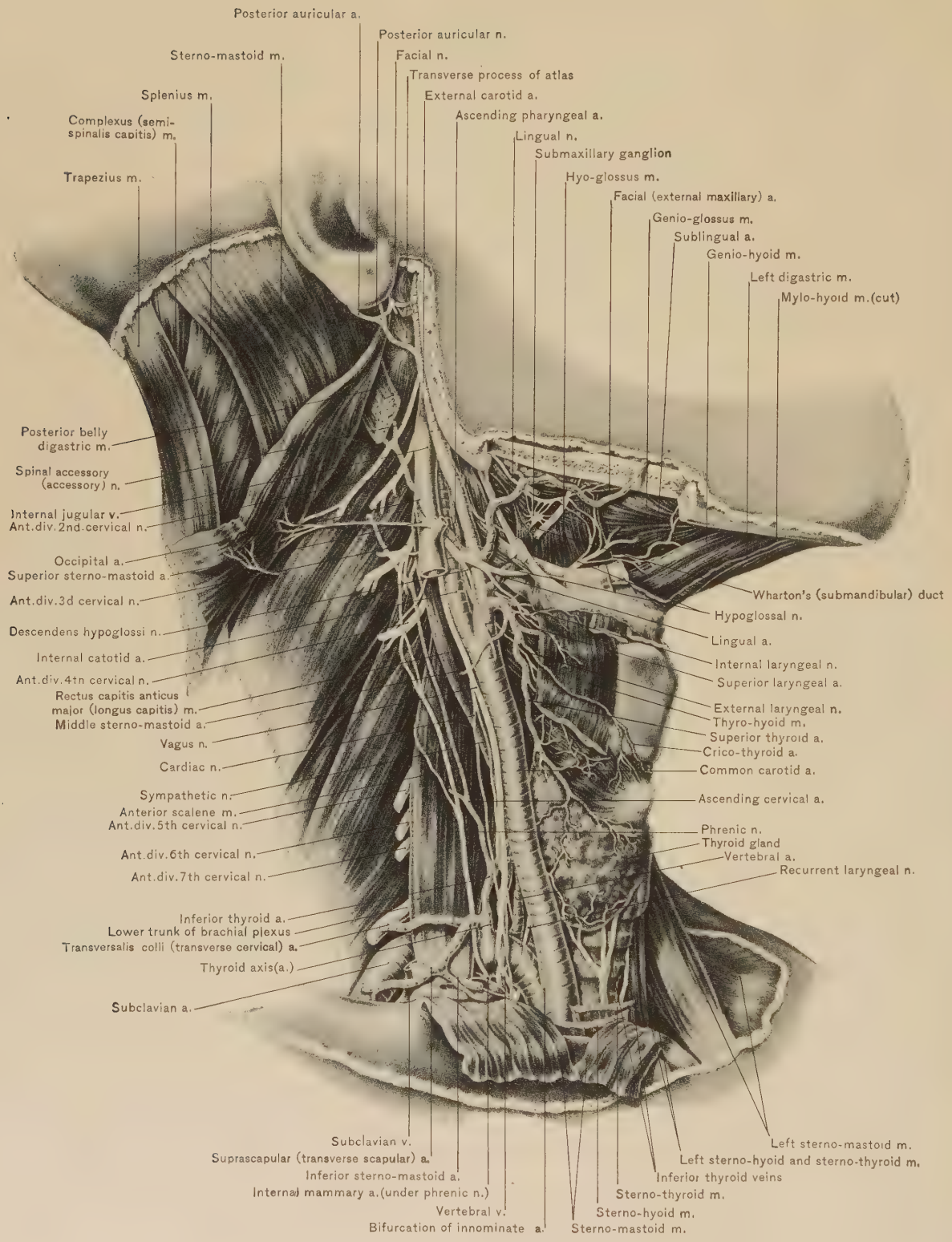
The **internal jugular vein** is the continuation of the lateral (*transverse*) sinus, and begins at the jugular foramen, where the sinus is joined by the inferior petrosal sinus. It is the largest of the superficial veins in the body. The vein is somewhat dilated at its origin, this enlargement forming the *superior bulb*, which lies in the jugular fossa. At the jugular foramen the vein lies behind and lateral to the glosso-pharyngeal, the vagus, and the spinal accessory (*accessory*) nerves. It passes down the side of the neck, at first beneath and lateral to the internal carotid artery, then on the lateral side of the internal carotid, and finally, on the lateral side of the common carotid artery. It terminates by joining the subclavian vein just lateral to the upper margin of the sterno-clavicular articula-

PLATE CCXLVIII.



MUSCLES AND NERVES OF NECK.

PLATE CCXLIX.



DEEP STRUCTURES OF NECK,—CAROTID ARTERIES AND VAGUS NERVE.

tion to form the innominate vein. A little above its termination is another somewhat spindle-shaped enlargement, the *inferior bulb*. The vein occupies a lateral position in the carotid sheath, and is separated from the common carotid artery and vagus nerve by septa. At the lower part of the neck the two internal jugular veins observe a slightly different course. The *right internal jugular* at its termination leaves the right common carotid artery to join the subclavian vein, forming a triangular interval between the artery and vein, while the *left internal jugular* turns forward to join the subclavian vein, and overlaps the left common carotid artery at the root of the neck. The internal jugular vein has a pair of valves about two centimeters (three-fourths of an inch) from its termination. Opposite the angle of the mandible, a communicating branch from the external jugular vein and some pharyngeal veins empty into it. Near the level of the greater cornu of the hyoid bone it receives the facial (*anterior facial*) and lingual veins; lower down it receives the superior thyroid vein, and opposite the cricoid cartilage, the middle thyroid vein. The internal jugular and other veins of the neck empty during inspiration. Inspiration of a large quantity of air when the jugular is opened during an operation may lead to air embolus. This vein may become infected secondarily to sinus thrombosis. Ligation should be done in two places and the vessel divided between the ligatures.

The common carotid artery (Plates CCXLVIII; CCXLIX).—The right and left common carotid arteries do not have the same origin, but as they occupy the same relative position in the neck only one artery will be described. The *right common carotid* arises from the innominate artery behind the upper margin of the right sterno-clavicular articulation; *the left common carotid* arises from the highest part of the transverse portion of the arch of the aorta; this origin within the chest makes it the longer of the two vessels. It may be divided into a thoracic and a cervical portion. The thoracic portion will be described with the chest.

The *course* of the common carotid, external carotid, and internal carotid arteries, when the face is turned slightly to the opposite side, is represented by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the mandible and the mastoid process of the temporal bone. The portion of the line below the level of the upper border of the thyroid cartilage indicates the course of the common carotid, and the part above the upper border of the thyroid cartilage, the position of the internal and external carotid arteries. The latter deviates slightly from this line toward the angle of the mandible.

At the lower part of the neck the common carotid artery is situated deep beneath the sternal origin of the sterno-mastoid, the sterno-hyoid, and the sterno-thyroid muscles, being separated from its fellow by the trachea. Thence it ascends in the medial compartment of the sheath of the vessels, beneath the

anterior border of the sterno-mastoid muscle, to terminate opposite the upper border of the thyroid cartilage by bifurcating into the external and internal carotid arteries. At the bifurcation one occasionally finds a small gland-like body, known as the carotid body. It consists chiefly of chromaffin cells. As the artery ascends it diverges from the median line, on account of the interposition of the lateral lobe of the thyroid gland between it and the trachea, and on account of the width of the larynx. It is covered by the skin, superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the anterior border of the sterno-mastoid muscle, and the anterior wall of the carotid sheath; in addition to these, at the lower part of the neck are the sterno-hyoid and sterno-thyroid muscles, the thyroid gland, which slightly overlaps it, the omo-hyoid muscle and the anterior jugular vein, which cross it. The descendens hypoglossi nerve and ansa hypoglossi also lie in front of it, and it is crossed by the middle sterno-mastoid artery and the superior and middle thyroid veins. Behind it are the rectus capitis anterior major (*longus capitis*) and the longus colli muscles, the vagus, the sympathetic, and cardiac nerves, the recurrent laryngeal nerve, at the lower part of the neck, and the inferior thyroid artery crossing behind it at the level of the cricoid cartilage. To the medial side of the artery are the trachea and the esophagus, the recurrent laryngeal nerve lying between them, the lateral lobe of the thyroid gland, the terminal portion of the inferior thyroid artery, the larynx, the pharynx, and the superior thyroid artery. To the lateral side of the artery are the internal jugular vein and the vagus nerve.

The common carotid artery seldom gives off branches, but when the bifurcation is higher than usual, it may give off the superior thyroid artery. The bifurcation of the artery may occur higher or lower than the upper border of the thyroid cartilage, and is frequently situated opposite the greater cornu of the hyoid bone.

Aneurysms of the common carotid artery, although not frequent, usually develop near its bifurcation because of the anatomic dilatation at this point and because the vessel is more superficial in this region. Pressure upon the internal jugular vein by an aneurysm of the common carotid artery produces cyanosis or duskiness of the face and scalp, headache, and puffiness or edema of the face; pressure upon the sympathetic cord causes dilatation, and, later, contraction of the pupil; pressure upon the superior laryngeal nerve causes coughing and spasm or paralysis of one crico-thyroid muscle, and pressure upon the recurrent laryngeal nerve produces spasm or paralysis of the muscles of one side of the larynx, hoarseness, and difficulty in phonation. These aneurysms at the side of the neck produce a pulsating swelling which resembles that seen in enlargement of a lateral lobe of the thyroid gland. As the thyroid gland adheres

to the trachea, enlargements or tumors of that organ move upward and downward with the larynx and trachea during deglutition, whereas an aneurysm of the common carotid artery remains stationary.

Ligation of the common carotid artery or one of its branches may be required for the treatment of wounds or aneurysms of this artery. It is best to place the ligature at the superior carotid triangle, opposite the cricoid cartilage and immediately above the point where the omohyoid muscle crosses its sheath. The incision is made along the anterior border of the sterno-mastoid muscle, cutting through the skin, the superficial fascia, the platysma muscle, and the superficial layer of the deep fascia; the sterno-mastoid is then displaced lateralward, thus exposing the sheath with the descendens hypoglossi nerve upon it. As the internal jugular vein slightly overlaps the lateral side of the artery, a small incision should be made in the medial side of the sheath, and the needle passed from without medialward, avoiding the internal jugular vein and the vagus nerve. The opening in the sheath should be small, so that the vasa vasorum and the nutrition of the vessel need not be unnecessarily disturbed. In exposing the carotid sheath, the superior, or middle, thyroid vein and the middle sterno-mastoid artery may be severed. Placing the ligature in the inferior carotid triangle is more difficult and more dangerous because the artery is deeper and covered by three layers of muscles: the sterno-thyroid, sterno-hyoid, and sterno-mastoid; on the left side, the internal jugular vein turns forward in front of the artery at the root of the neck to join the subclavian vein.

The carotid body, or ganglion (**glomus caroticum**), is a small, oval, reddish-brown body situated in the interval between the external and internal carotid arteries, behind the bifurcation of the common carotid. It receives filaments from the cervical sympathetic, and resembles the coccygeal body (*glomus coccygium*), or Luschka's gland, the cells, however, being of the chromaffin type.

The Vagus, or Pneumogastric, Nerve (Plate CCXLIX).—The vagus nerve, the tenth and longest of the cranial nerves, has an extensive area of distribution. It supplies branches to: the dura mater, external ear, pharynx, larynx, esophagus, trachea, bronchi, lungs, stomach, spleen, liver, gall bladder, and the intestinal tract as far down as the sigmoid. The fibers to the viscera are known as the parasympathetic fibers, and have an antagonistic action to those of the thoracolumbar outflow of the sympathetic system. It leaves the cranial cavity at the jugular foramen, inclosed within the same sheath of the dura mater as the spinal accessory (*accessory*) nerve. It runs downward between the internal jugular vein and the internal carotid artery, passes between the internal jugular vein and the common carotid artery, lying behind and between them in the posterior compartment of their sheath, and enters the chest at its superior opening. On the

right side, it passes between the first portion of the subclavian artery and the subclavian vein, while on the left side it runs between the first portion of the subclavian artery and the common carotid artery, beneath the left innominate vein. (Its course in the chest is described with the chest.) (See Vol. III.) The vagus nerve, owing to its position between the internal jugular vein and the internal carotid artery, is closely associated with the glosso-pharyngeal, the spinal accessory (*accessory*), and the hypoglossal nerves. These nerves accompany the internal carotid artery for only a short distance, the glosso-pharyngeal nerve curving anteriorly between the external and internal carotid arteries, the spinal accessory (*accessory*) turning posteriorly beneath the internal jugular vein, and the hypoglossal curving anteriorly over the internal and external carotid arteries and the root of the occipital artery.

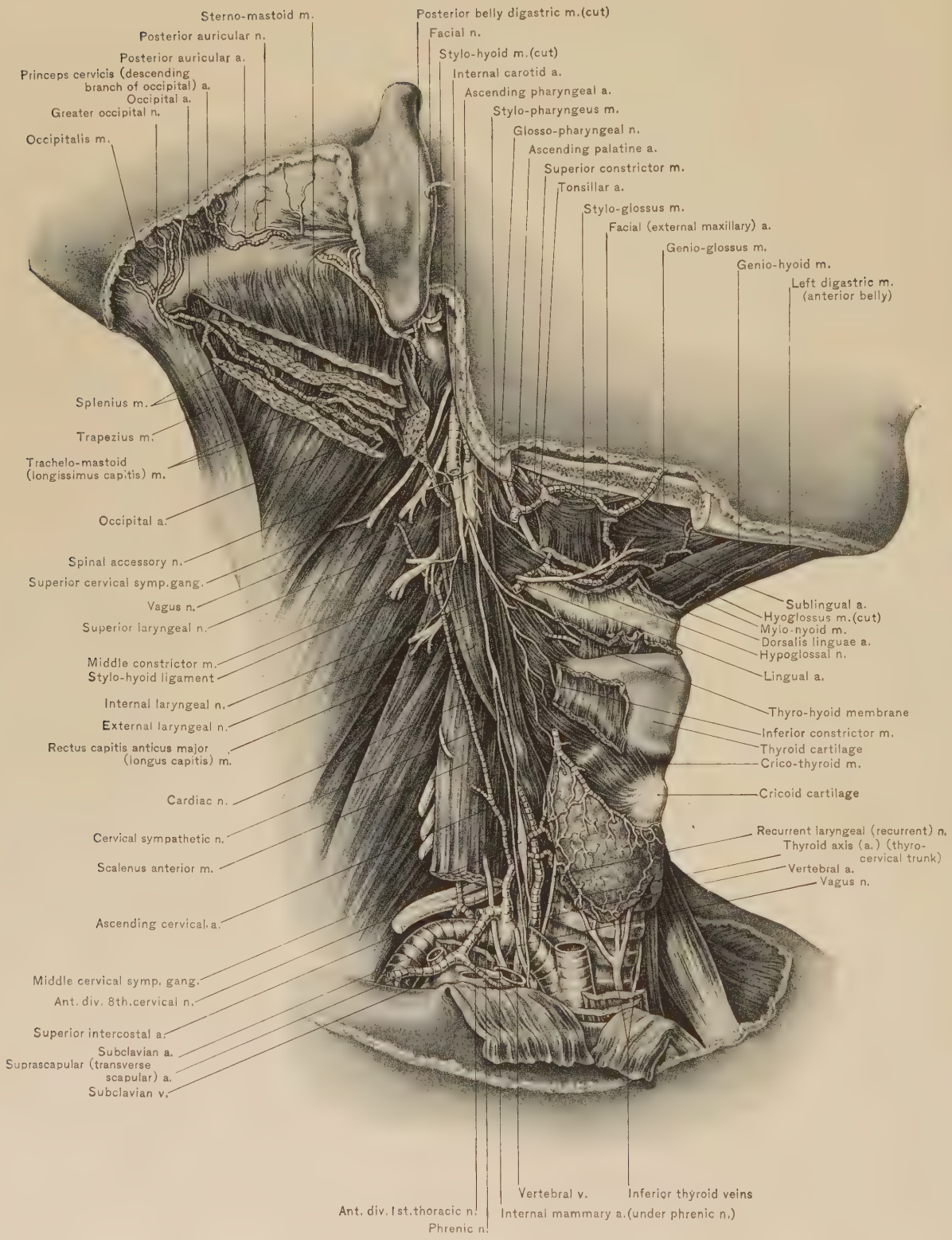
There are two ganglia on the vagus nerve: the *ganglion of the root* (the *superior*, or *jugular, ganglion*), a small, rounded swelling seen upon the nerve as it lies in the jugular foramen, and the *ganglion of the trunk* (the *inferior ganglion*, or *ganglion nodosum*), a long, fusiform enlargement, situated upon the nerve about twelve millimeters (one-half inch) below the jugular foramen. It is closely associated with the hypoglossal nerve, which winds around its lateral side; below this ganglion, the vagus receives some fibers from the accessory portion of the spinal accessory (*accessory*) nerve.

Branches of the Vagus Nerve are communicating branches and branches of distribution. The *communicating branches* connect it with the facial, glosso-pharyngeal, spinal accessory, hypoglossal, cervical sympathetic, and the first two cervical nerves. The *branches of distribution* are: in the jugular foramen, the meningeal and the auricular nerves; in the neck, the pharyngeal, superior laryngeal, right recurrent laryngeal (*recurrent*), and cervical cardiac nerves; in the chest, the thoracic cardiac (*left recurrent*), anterior and posterior pulmonary (*bronchial*), and esophageal nerves; in the abdomen, visceral branches.

The **meningeal, or recurrent, branch** is a small twig which runs upward from the ganglion of the root (*jugular ganglion*), through the jugular foramen, to the dura mater, especially in the region of the lateral (*transverse*) and occipital sinuses.

The **auricular branch,** Arnold's nerve, arises from the ganglion of the root of the vagus (*jugular ganglion*), receives a branch from the the petrous ganglion of the glosso-pharygneal nerve, and passes over the superior bulb of the internal jugular vein to reach an aperture in the lateral wall of the jugular fossa. It next passes through the temporal bone near the facial canal, communicating with the facial nerve, and emerging from the bone between the mastoid process and the external auditory meatus. Turning lateralward, it supplies the back of the auricle and part of the external auditory canal, one of its branches communicat-

PLATE CCL



CERVICAL SYMPATHETIC NERVE AND LARYNGEAL NERVES.

ing with the posterior auricular branch of the facial nerve. Irritation of this nerve by a foreign body in the external auditory meatus may induce a cough, which persists until the foreign body is removed. This *ear cough* is explained by the common central connection of the auricular and superior larygneal branches of the vagus nerve.

The **pharyngeal branch,** the chief motor nerve of the pharynx, arises from the ganglion of the trunk (*ganglion nodosum*) and receives part of the accessory portion of the spinal accessory nerve. It runs behind or in front of the internal carotid artery to the back of the pharynx, to the upper border of the middle constrictor muscle, where it assists in forming the *pharyngeal plexus.* This plexus is formed by branches of the glosso-pharyngeal and vagus nerves and branches of the superior cervical sympathetic ganglion. The pharyngeal muscles and mucous membrane and the azygos uvulæ (*uvular*) and levator palati (*levator veli palatini*) muscles are supplied by filaments from this plexus.

The **superior laryngeal nerve** (Plate CCL), the sensory nerve of the larynx, arises from the ganglion of the trunk (*ganglion nodosum*) of the vagus nerve, curving downward and forward behind the internal and external carotid arteries, and dividing into an external and an internal laryngeal branch. The *internal branch,* together with the superior laryngeal artery, enters the larynx through the thyro-hyoid membrane, supplying the laryngeal mucous membrane and the arytenoid muscle, and communicating with the recurrent laryngeal nerve. The *external branch,* which is much smaller than the internal, descends along the side of the pharynx under the sterno-thyroid muscle; it supplies the crico-thyroid muscle and membrane, the inferior constrictor muscle of the pharynx, and the thyroid gland; it also sends filaments to the pharyngeal plexus, and behind the common carotid artery gives off a branch to the superior cardiac nerve of the cervical sympathetic.

Paralysis of the superior laryngeal nerve may be due to pressure of an aneurysm of the external or the internal carotid artery or to enlarged lymph glands or to tumors. The external laryngeal division may also be compressed by an aneurysm of the upper part of the common carotid artery. Anesthesia of the laryngeal mucous membrane would permit foreign bodies to enter the larynx, and cause inflammation or obstruction. Paralysis of the crico-thyroid muscle prevents stretching of the vocal cords and causes a hoarse and low pitched voice.

Irritation of the superior laryngeal nerve by aneurysm of the internal or the external carotid artery, or by an enlarged thyroid gland or lymph glands, causes a peculiar, unproductive, ringing cough.

The **recurrent laryngeal** (**recurrent**) **nerves** are the motor nerves of the larynx, supplying all of the intrinsic muscles of that organ except the crico-thyroid,

which is supplied by the external laryngeal branches of the superior laryngeal nerves. The *right recurrent laryngeal nerve* is shorter than the left; it arises from the vagus nerve as it crosses the first portion of the right subclavian artery, it then winds behind the first portion of the right subclavian artery, ascending obliquely in front of the apex of the right pleural sac and behind the root of the right common carotid artery and the terminal portion of the inferior thyroid artery, to reach the groove between the trachea and the esophagus. In the groove, it passes behind and medial to the right lateral lobe of the thyroid body, and leaves the groove to reach the intrinsic muscles of the larynx by passing behind the inferior cornu of the thyroid cartilage.

Pressure upon this nerve may be caused by aneurysm of the first portion of the right subclavian artery or of the lowermost portion of the right common carotid artery, by enlargement of the thyroid body, cicatrices of the apex of the right pleura, as in phthisis, or by malignant disease of the esophagus or of the superior mediastinum.

The *left recurrent laryngeal nerve* arises from the vagus nerve in front of the transverse portion of the arch of the aorta, and winds behind that portion of the arch below and to the left side of the obliterated ductus arteriosus. It next ascends behind the root of the left common carotid artery to the groove between the trachea and the esophagus, continuing upward to the larynx, and passing behind and medial to the left lateral lobe of the thyroid gland, in a course similar to that of the right recurrent laryngeal nerve. Both nerves communicate with the superior laryngeal nerve of the same side and with the cervical sympathetic.

Pressure upon the left recurrent laryngeal nerve may be produced by aneurysm of the arch of the aorta or of the lowermost portion of the left common carotid artery, by tumors of the posterior mediastinum, by enlargement of the thyroid gland, or by malignant disease of the esophagus or of the mediastinum. Irritation of the nerve, such as occurs early in some of the aortic aneurysms, causes a brassy cough and stridulous respirations. Moderate pressure causes spasm of the muscles of the same side of the larynx, dyspnœa, and change of voice. Greater pressure causes paralysis and alteration of the voice. Both nerves may be involved in bulbar palsy, or disseminated sclerosis of the pons, the medulla oblongata, and the spinal cord, or by pressure from an enlarged thyroid gland or carcinoma of the esophagus. When both nerves are paralyzed the vocal cords are immovable, phonation is imperfect, and the rima glottidis is in the relaxed position assumed in quiet breathing.

Involvement of one or the other of the recurrent laryngeals is commoner than it is often thought to be. Before operating for disease of the thyroid it is well to examine the larynx for vocal cord involvement, since one may otherwise

think a lesion developing later was due to injury at the time of operation. The proximity of the nerve to the inferior thyroid artery makes inferior thyroid ligation without very careful exposure dangerous.

The **cervical cardiac branches of the vagus nerve** are given off in the upper and lower part of the neck. The *superior cervical cardiac branches* join the cardiac branches of the cervical sympathetic and terminate in the deep cardiac plexus. The *left inferior cervical cardiac branch* passes between the pleura and the left side of the transverse portion of the aortic arch, entering the superficial cardiac plexus with the left superior cervical cardiac branch of the cervical sympathetic. The *right inferior cervical cardiac branch* passes on the trachea to the deep cardiac plexus.

The **thoracic and abdominal branches of the vagus nerve** will be described with the thorax and the abdomen.

The Cervical Sympathetic (Plate CCL).—The sympathetic nervous system is that portion of the peripheral nervous system which is chiefly concerned in the carrying of impulses to the blood-vessels, the heart, the glandular tissues, and the smooth-muscle viscera. The sympathetic fibers are found in every part of the body, although they are most abundant in the abdominal cavity. The system is by no means independent of the cerebro-spinal system. The sympathetic nervous system consists of a series of ganglia, joined one to the other by connecting nerve cords; it is also composed of gangliated plexuses, visceral ganglia, and many nerve fibers. The nerve fibers of the sympathetic system are chiefly non-medullated, and when medullated near their cells of origin become non-medullated before their termination.

The cervical portion of the sympathetic is situated behind the carotid sheath or in its posterior wall, and lies beneath the prevertebral fascia, where it rests upon the rectus capitis anterior major (*longus capitis*) and the longus colli muscles. Three cervical ganglia, the superior, middle, and inferior, lie in each side of the neck. This portion of the sympathetic system contains both medullated and non-medullated fibers. The white rami enter from the upper thoracic region, the cervical nerves having no white rami communicantes.

The superior cervical ganglion, the largest of the three, is a long, fusiform, reddish-gray body situated opposite the transverse processes of the second and third cervical vertebræ, behind the sheath of the great vessels. It is probably formed by the fusion of four ganglia, corresponding to the upper four spinal nerves. It is in relation in front, with the sheath of the internal carotid artery and internal jugular vein and behind, with the rectus capitus anterior major (*longus capitis*) muscle. It gives off branches of communication and branches of distribution.

The *branches of communication*, or *somatic branches*, consist of gray *rami communicantes* which connect the ganglion with the first four cervical nerves, and of *communicating branches* to the petrous ganglion of the glosso-pharyngeal, to the hypoglossal, and to the root (*jugular*) ganglion and the trunk ganglion (*ganglion nodosum*) of the vagus nerve.

The *branches of distribution*, or *visceral branches*, are: the pharyngeal, superior cardiac, vascular and vertebral branches.

The *pharyngeal branches* pass behind the carotid sheath, and together with pharyngeal branches of the glosso-pharyngeal and vagus nerves form the *pharyngeal plexus*.

The *superior cardiac* branch arises from the lower part of the superior cervical sympathetic ganglion or from the trunk which connects it with the middle cervical ganglion. It runs downward behind the carotid sheath, communicating with the superior cardiac branch of the vagus, the external laryngeal, and the recurrent laryngeal nerves. In the chest the course of the nerve differs on the two sides. The right nerve passes in front of or behind the first portion of the subclavian artery, following the innominate artery and terminating in the *deep cardiac plexus;* on the left, it passes between the left common carotid and the left subclavian arteries and over the left side of the arch of the aorta to the left of the vagus nerve, terminating in the *superficial cardiac plexus*.

The vascular branches are plexiform nerve structures accompanying the terminal divisions of the common carotid artery; they are the external and the internal carotid branches.

The *external carotid branches, nervi molles*, ramify upon the external carotid artery and its branches, forming the plexuses of the facial and middle meningeal arteries. They supply branches to the carotid body (*glomus caroticum*); those on the facial artery supply branches to the submaxillary ganglia (the sympathetic root), while those upon the middle meningeal artery send branches to the sympathetic root of the otic ganglion and a branch, the *external superficial petrosal nerve*, to become the sympathetic root of the geniculate ganglion.

The *internal carotid branch* is the *ascending branch* of the superior ganglion. It passes upward through the carotid canal with the carotid artery. It divides into an external branch which forms the *carotid plexus*, and an internal branch which forms the *cavernous plexus*. Both these plexuses supply the artery and its branches, and communicate with certain cerebral nerves. The dilator fibers of the iris come from these branches.

The **middle cervical, or thyroid, ganglion,** the smallest of the three ganglia, appears as a swelling upon the sympathetic trunk; it is occasionally absent. It rests upon or beneath the inferior thyroid artery, opposite the transverse process

of the sixth cervical vertebra, and is probably formed by the fusion of two ganglia, corresponding to the fifth and sixth cervical nerves. It gives off communicating branches to the superior and inferior cervical ganglia and the middle cardiac nerve.

The *communicating*, or *somatic, branches* are the gray rami communicantes, which pass to the fifth and sixth cervical nerves.

The *subclavian loop*, or *communicating branches to the inferior ganglion*, are the main sympathetic trunk, which passes behind the first portion of the subclavian artery, and one or two nerves which form a loop, the ansa Vieussenii (*ansa subclavia*), in front of and below the artery.

The *visceral branches* are the thyroid plexus and the middle cardiac nerve. The *thyroid plexus* accompanies the inferior thyroid artery into the thyroid body.

The *middle cardiac nerve*, the largest of the three cervical sympathetic cardiac nerves, arises from the middle ganglion or from the trunk between the middle and the inferior ganglia. It communicates with the superior cardiac and the recurrent laryngeal nerve, and on the right side passes in front of or behind the first portion of the subclavian artery, entering the deep cardiac plexus; on the left, it enters the thorax between the common carotid and subclavian arteries.

The **inferior cervical ganglion** is intermediate in size between the middle and superior ganglia. It is deeply situated between the transverse process of the seventh cervical vertebra and the neck of the first rib, and lies to the medial side of the superior intercostal artery, behind the vertebral artery. It is formed, probably, by the fusion of two ganglia, corresponding to the seventh and eighth cervical nerves. It is joined to the first thoracic ganglion by two large nerves, and may be fused with that ganglion. The sympathetic cord and the ansa Vieussenii (*ansa subclavia*) connect it with the middle cervical ganglion. It gives off communicating and visceral branches. The *communicating*, or *somatic, branches* are *gray rami communicantes* to the seventh and eighth cervical nerves, the *ansa Vieussenii* (*ansa subclavia*) which connects it with the middle cervical ganglion, and a *communicating branch to the inferior laryngeal nerve.*

The *visceral branches* are the inferior cardiac nerve and branches which form a plexus on the vertebral artery.

The *inferior cardiac nerve* arises from the inferior cervical ganglion, or occasionally from the first thoracic ganglion. It passes behind the subclavian artery, communicating with the recurrent laryngeal and the middle cardiac nerve, and descending upon the trachea to enter the deep cardiac plexus.

The branches forming the *vertebral plexus* upon the vertebral artery accompany the vessel into the cranial cavity, after which they follow the basilar and cerebral arteries.

The cervical sympathetic may be injured in wounds, infections, or tumors of the neck. It is supposed that the exophthalmos of toxic goiter is due to sympathetic stimulation. Ligation of the superior thyroid artery at the upper pole of the gland, instead of at its origin, is based on the assumption that the sympathetics to the thyroid are ligated at the same time. The main trunk has been severed by Jonnesco, and others, for exophthalmic goiter, epilepsy and more recently for angina pectoris. The nerve may be exposed by an incision anterior to the sterno-mastoid, since it lies on the prevertebral fascia, back of the carotid sheath.

The **External Carotid Artery** (Plates CCXLIX; CCLI), so called because it supplies the tissues on the outside of the cranium, is the smaller of the two terminal divisions of the common carotid artery. It arises opposite the upper border of the thyroid cartilage, ascends, and enters the parotid gland, where it lies beneath the temporo-maxillary (*posterior facial*) vein and the facial nerve. Opposite the neck of the mandible it divides into its two terminal branches, the superficial temporal and internal maxillary arteries. At first it lies to the medial side of the internal carotid artery, but later becomes superficial to that vessel.

Relations.—It is covered by the skin, superficial fascia, the platysma muscle, the superficial layer of the deep cervical fascia, the anterior border of the sterno-mastoid muscle, and a portion of the parotid gland, the temporo-maxillary vein (*posterior facial*), and the facial nerve. It is crossed by the hypoglossal nerve, the facial (*anterior facial*) and lingual veins, the posterior belly of the digastric muscle, and the stylo-hyoid muscle, and enters the parotid gland. Along the medial side of the vessel, from below upward, are the wall of the pharynx, the hyoid bone, the ramus of the mandible, and the stylo-maxillary (*stylo-mandibular*) ligament, from which it is separated by a portion of the parotid gland. Beneath it, near its origin, is the superior laryngeal nerve; higher in the neck, it is separated from the internal carotid artery by the stylo-glossus and stylo-pharyngeus muscles, the stylo-hyoid ligament, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus nerve, and part of the parotid gland. The external carotid artery differs from most of the arteries in not having a companion vein, although occasionally it is accompanied by a vein formed by the union of the superficial temporal and internal maxillary veins.

A *line* drawn from the junction of the sternum with the clavicle to a point midway between the angle of the mandible and the mastoid process represents the course of the common and external carotid arteries. The line for ligation is from the level of the angle of the mandible to the middle of the thyroid cartilage.

The Branches of the External Carotid Artery (Plate CCLII) are: the superior thyroid, lingual, facial (*external maxillary*), occipital, posterior auric-

PLATE CCLI.

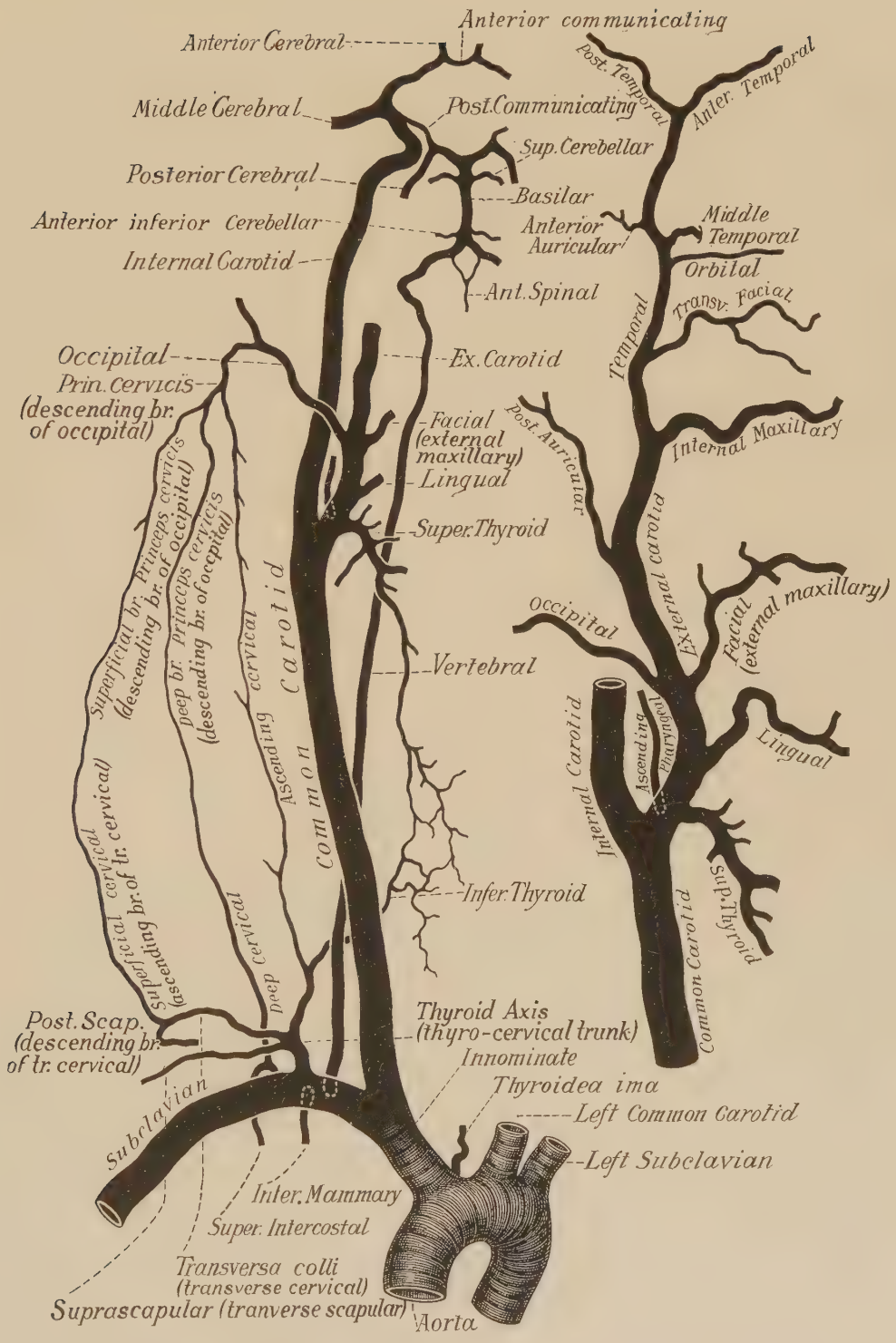


DIAGRAM OF SUBCLAVIAN AND CAROTID ARTERIES AND THEIR BRANCHES

ular, ascending pharyngeal, superficial temporal, and internal maxillary arteries. They may be divided into four sets: an *anterior set*, comprising the superior thyroid, lingual, and facial (*external maxillary*); a *posterior set*, comprising the occipital, and posterior auricular; an *ascending set*, consisting of the ascending pharyngeal, and a *terminal set*, comprising the superficial temporal, and internal maxillary arteries.

The **superior thyroid artery**, the first branch given off from the external carotid, arises just below the greater cornu of the hyoid bone. Throughout the greater part of its course it occupies the superior carotid triangle. It passes forward and then downward and medialward behind the omo-hyoid, sterno-thyroid, and sterno-hyoid muscles to the upper and front part of the thyroid gland, in which it terminates. Its branches are the hyoid, middle sterno-mastoid, superior laryngeal, and crico-thyroid arteries. In ligating the superior thyroid distal to the superior thyroid pole, one must keep in mind the fact that the superior laryngeal nerve is just posterior to the artery.

The *hyoid artery* is very small. It runs medialward along the lower border of the hyoid bone, beneath the thyro-hyoid muscle, supplying the infrahyoid bursa and the thyro-hyoid muscle, and communicates with the infrahyoid artery of the opposite side and with the suprahyoid branch of the lingual artery.

The *middle sterno-mastoid artery* passes downward and lateralward over the sheath of the common carotid artery in the superior carotid triangle, the triangle of election; it is chiefly distributed to the middle portion of the sterno-mastoid muscle, supplying also the thyro-hyoid, sterno-thyroid, sterno-hyoid, omo-hyoid, and platysma muscles, and the overlying skin. Sometimes this vessel is unusually large, running into the occipital triangle, and giving rise to fatal hemorrhage if injured when incising an abscess.

The *superior laryngeal artery*, larger than either of the two preceding branches, is accompanied by the internal branch of the superior laryngeal nerve; it passes beneath the thyro-hyoid muscle and pierces the thyro-hyoid membrane, supplying the muscles and mucous membrane of the larynx, and anastomosing with the superior laryngeal artery of the opposite side and the inferior laryngeal branch of the inferior thyroid artery. At times it enters the larynx through a foramen in the thyroid cartilage.

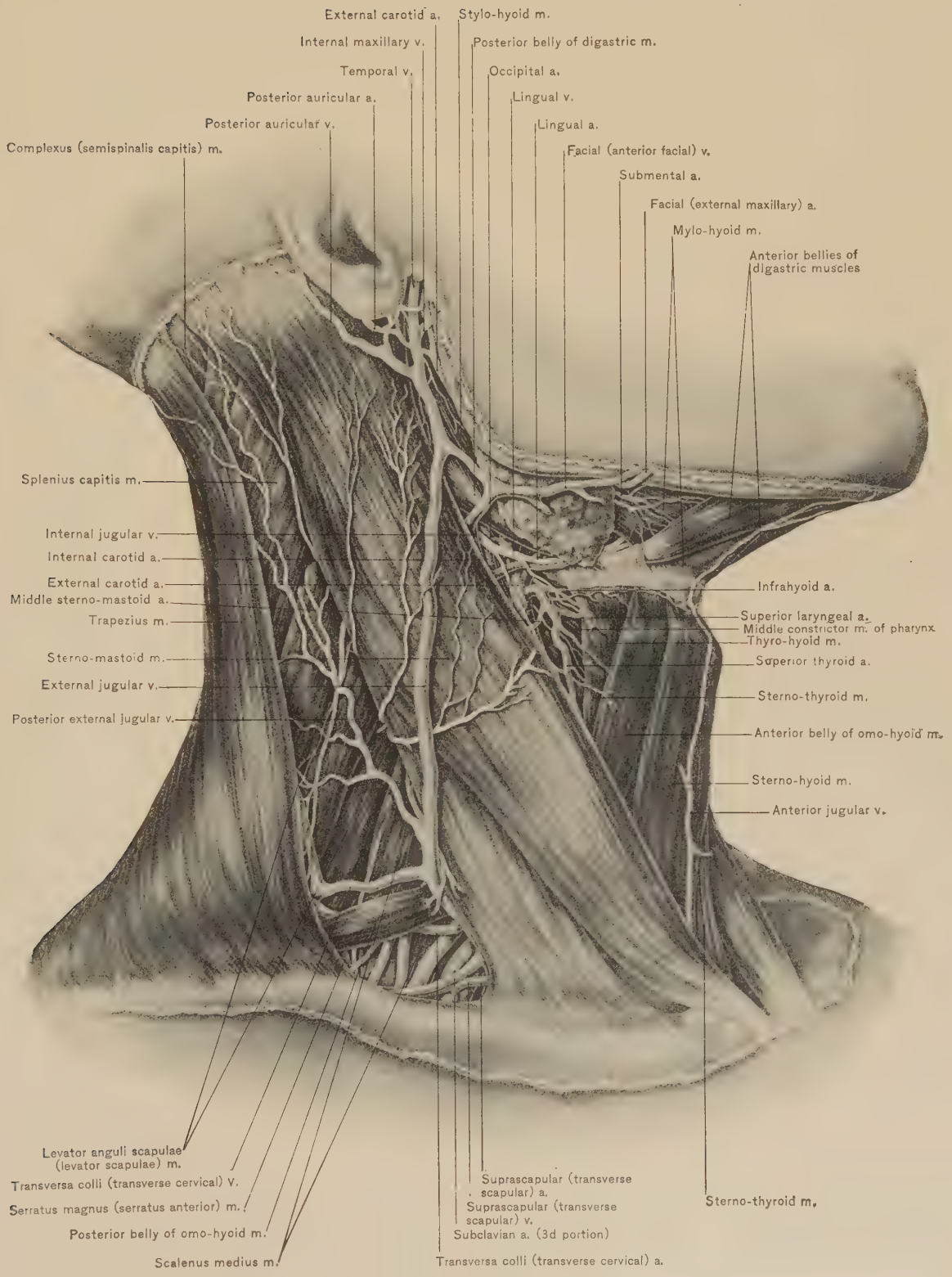
The *crico-thyroid artery* runs across the crico-thyroid membrane, just below the lower border of the thyroid cartilage, and is continuous with the crico-thyroid artery of the opposite side. A small branch usually passes through the crico-thyroid membrane to the interior of the larynx. The operation of laryngotomy is performed by carrying a transverse incision through the crico-thyroid mem-

brane, close to the cricoid cartilage; it is therefore important to keep in mind the relation which the crico-thyroid artery bears to the membrane, and the necessity, time permitting, for exposing the membrane by careful dissection.

The **superior thyroid vein** (Plate CCXLVII), the accompanying vessel of the superior thyroid artery, crosses the terminal part of the common carotid artery, and empties into the internal jugular vein; sometimes it enters the facial (*anterior facial*) or the lingual vein. It emerges from the upper part of the lateral lobe of the thyroid gland, accompanying the superior thyroid artery for a short distance, and then crossing the common carotid artery to empty into the internal jugular vein. A branch of the vein, or one which arises separately in the thyroid gland, usually passes upward and anterior to the common carotid and the external carotid arteries, and empties into the lingual vein.

The **lingual artery** (Plate CCLII), the second branch of the external carotid, arises opposite the greater cornu of the hyoid bone between the superior thyroid and the facial (*external maxillary*) arteries, occasionally arising as a common trunk with the latter. It consists of three portions: the *first*, or oblique, portion lies between its origin and the lateral border of the hyoglossus muscle; the *second*, or horizontal, portion lies beneath the hyoglossus muscle and parallel with the greater cornu of the hyoid bone, and the *third*, or ascending, portion lies between the hyoglossus and the genio-glossus muslces. The *first*, or oblique, portion lies in the superior carotid triangle, and runs upward and medialward to the upper border of the greater cornu of the hyoid bone, resting upon the middle constrictor muscle of the pharynx and the internal laryngeal branch of the superior laryngeal nerve. Thence it passes beneath the hyoglossus, the posterior belly of the digastric, and the stylo-hyoid muscle, emerging from the superior carotid triangle and entering the submaxillary (*submandibular*) triangle. This portion of the vessel is crossed by the hypoglossal nerve and the lingual vein, and gives off the suprahyoid branch. The *second*, or horizontal, portion runs beneath the hyoglossus muscle. The *third*, or ascending, portion passes beneath the anterior border of the hyoglossus on the lateral aspect of the genioglossus muscle, and runs forward to the tip of the tongue, terminating as the *ranine* (*profunda linguæ*) *artery;* the terminal portion of the lingual artery is separated from the cavity of the mouth by the mucous membrane which lines it. (See description of submaxillary triangle at p. 489.) The lingual artery must often be tied in malignant disease of the mouth, as a preliminary to the use of radium or electro thermiccoagulation. It is also ligated when a whole or a part of the tongue is to be excised. The ligation of the vessel is discussed at p. 491. In ligating for malignant lesions it is preferable to ligate the lingual at its origin. This allows for the simultaneous tying of

PLATE CCLII.



SUPERFICIAL STRUCTURES OF NECK.

the facial (*external maxillary*) artery. The anastomoses between these two vessels is sufficient to cause extensive secondary hemorrhage if both are not ligated.

The *lingual vein* is seen crossing the first portion of the lingual artery with the hypo-glossal nerve. It runs over the external carotid artery, and opposite the greater cornu of the hyoid bone it empties into the internal jugular vein either separately, or by a common trunk with the facial (*anterior facial*) vein and a branch of the superior thyroid vein. These veins and their common trunk may cause some difficulty in ligation of the common carotid or the first portion of the lingual artery. The lingual vein usually lies on the hyoglossus muscle and below the hypoglossal nerve. The artery lies under the muscle.

The **facial** (**external maxillary**) **artery** arises from the external carotid above the lingual artery, passes upward beneath the posterior belly of the digastric and the stylo-hyoid muscles and the submaxillary (*submandibular*) gland, being embedded in a groove on the under surface of the latter; it then curves upward over the body of the mandible, reaching the face at the anterior inferior angle of the masseter muscle, where the artery can be compressed and its pulsations readily felt. It consists of two portions, a cervical and a facial.

The BRANCHES given off from the CERVICAL PORTION of the FACIAL (EXTERNAL MAXILLARY) ARTERY are the ascending palatine, the tonsillar, the submaxillary (*glandular*), the submental, and the muscular.

The *ascending palatine artery* occasionally arises separately from the external carotid artery. It ascends between the internal and external carotid arteries, then runs between the stylo-glossus and stylo-pharyngeus muscles, and finally between the internal pterygoid muscle and the superior constrictor muscle of the pharynx. Reaching the levator palati (*levator veli palatini*) muscle, it divides into a palatine and a tonsillar branch; the *palatine branch* follows the course of the levator palati (*levator veli palatini*) muscle to supply the soft palate, and anastomoses with the ascending palatine artery of the opposite side, the descending palatine (*greater palatine*) branch of the internal maxillary artery, and the ascending pharyngeal artery; the *tonsillar branch* perforates the superior constrictor muscle of the pharynx; it supplies the tonsil and the Eustachian (*auditory*) tube, anastomoses with the tonsillar branches of the ascending pharyngeal and facial (*external maxillary*) arteries, and with the descending, or posterior palatine (*greater palatine*), branch of the internal maxillary artery.

The *tonsillar artery*, smaller than the ascending palatine artery, passes upward between the internal pterygoid and the stylo-glossus muscles. It perforates the superior constrictor muscle of the pharynx opposite the tonsil, and supplies branches to the tonsil and the root of the tongue. It anastomoses with the tonsillar branch of the ascending palatine and the other tonsillar arteries.

The *submaxillary (glandular) branches*, three or four in number, supply the submaxillary gland, and are derived from the portion of the artery in contact with the gland; some twigs usually run to Wharton's (*submandibular*) duct.

The *submental artery* is the largest of the branches given off from the cervical portion of the facial (*external maxillary*) artery. It arises from this vessel, beneath the submaxillary gland. It runs forward upon the mylo-hyoid muscle, under the lower border of the mandible and beneath the anterior belly of the digastric muscle, to the symphysis of the mandible, where it divides into a superficial and a deep branch. The superficial branch winds over the mandible and runs in the superficial fascia of the chin, anastomosing with the inferior labial artery. The deep branch runs beneath the depressor labii inferioris (*quadratus labii inferioris*) muscle, and anastomoses with the inferior labial and mental arteries. Its branches are *muscular*, which supply the posterior belly of the digastric, the stylo-hyloid, the stylo-glossus, the mylo-hyoid, and the internal pterygoid muscles; *perforating branches*, which pierce the mylo-hyoid muscle to anastomose with the sublingual artery, and *cutaneous branches* to the overlying skin. This artery is also ligated as a preliminary to the treatment of malignant disease of the mouth or tongue.

The **facial (anterior facial) vein** leaves the face at the anterior inferior angle of the masseter muscle. It passes over the submaxillary gland, the stylo-hyoid muscle and the posterior belly of the digastric muscle, which separate it from the facial (*external maxillary*) artery. It receives the anterior division of the temporomaxillary (*posterior facial*) vein, crosses the external carotid artery, and empties into the internal jugular vein opposite the greater cornu of the hyoid bone. In the face it lies posterior to the artery and its course is less tortuous. It may be injured in opening abscesses situated where it passes over the submaxillary gland.

The **occipital artery,** quite a large vessel, is one of the posterior branches of the external carotid artery. It arises opposite the facial artery, near the lower border of the posterior belly of the digastric muscle, along which it runs to the interval between the mastoid process of the temporal bone and the transverse process of the atlas, to reach the groove on the under surface of the mastoid portion of the temporal bone. At its origin it is crossed by the hypoglossal nerve. On its way to the mastoid process it crosses the internal carotid artery, the internal jugular vein, the vagus, hypoglossal, and spinal accessory (*accessory*) nerves, and passes beneath the lower portion of the parotid gland. It runs horizontally backward through the occipital groove of the temporal bone, covered by all the muscles attached to the mastoid process, the sterno-mastoid, splenius capitis, trachelo-mastoid (*longissimus capitis*), and the posterior belly of the digastric, and lies upon the superior oblique and complexus (*seminspinalis capitis*) muscles.

Reaching the back of the head, the artery pierces the trapezius muscle close to the superior curved (*superior nuchal*) line of the occipital bone, ascends, and divides into branches (see Dissection of the Scalp in Vol. I). As it pierces the trapezius muscle and ramifies in the superficial fascia of the scalp, it is accompanied by the greater occipital nerve. The occipital artery is conveniently divided by the sterno-mastoid muscle into three parts, first, second, and third portions, situated, respectively, medial to, beneath, and lateral to that muscle. The *first portion* is covered only by skin and fasciæ, except where it is overlapped by the posterior belly of the digastric muscle, the parotid gland, and the temporo-maxillary (*posterior facial*) vein. It is crossed by the hypoglossal nerve. Behind it successively lie the internal carotid artery, the hypoglossal and the vagus nerves, the internal jugular vein, and the spinal accessory (*accessory*) nerve. The first portion of the artery is the *place of election* for ligation. The *incision* is carried along the anterior border of the upper part of the sterno-mastoid muscle while the neck is well extended. Dividing the skin, superficial fascia, platysma muscle, and the superficial layer of the deep fascia will reveal the artery running parallel with or beneath the lower border of the digastric muscle, and the hypoglossal nerve curving around the artery at its origin. The *second portion* dips deep under the digastric muscle between the mastoid process of the temporal bone and the transverse process of the atlas, being covered, as previously stated, by the muscles attached to the mastoid process, and lying successively against the rectus capitis lateralis, which separates it from the vertebral artery, the mastoid portion of the temporal bone while passing through the occipital groove, and finally, against the insertion of the obliquus capitis superior muscle. The *third portion* emerges from beneath the posterior border of the sterno-mastoid and splenius muscles, lying upon the complexus (*semispinalis capitis*) in the triangular interval between the sterno-mastoid and the trapezius, and piercing the trapezius muscle about midway between the mastoid process and the external occipital protuberance, to become subcutaneous and pass upward in the superficial fascia of the scalp. It is accompanied by the greater occipital nerve. Ligation is more difficult than of the lingual and facial (*external maxillary*) arteries. Sometimes a mass ligature through the lower portion of the scalp will temporarily and even permanently suffice. If ligated near the mastoid process care should be taken not to injure the venous tributaries of the occipital vein from the mastoid, as these connect with the lateral sinus.

The Branches of the occipital artery are: muscular, superior sterno-mastoid, auricular, posterior meningeal, mastoid, princeps cervicis (*descending branch*), communicating, and terminal.

The *muscular branches* supply the digastric, stylo-hyoid, splenius, trachelo-mastoid (*longissimus capitis*), trapezius, recti, obliquus capitis superior and inferior, and the occipital (*occipital belly of epicranius*) muscles.

The *superior sterno-mastoid artery* enters the sterno-mastoid muscle with the spinal accessory (*accessory*) nerve. It arises from the first portion of the occipital artery, and passes downward and backward over the hypoglossal nerve to enter the sterno-mastoid muscle.

The *auricular branch* supplies the back of the auricle. At times it is large and takes the place of the posterior auricular artery; it may send a branch to the dura mater through the mastoid foramen.

The *posterior meningeal branches* ascend along the internal jugular vein, and enter the cranial cavity through the jugular foramen to supply the dura mater of the posterior cranial fossa.

The *mastoid branch* is a small vessel which traverses the mastoid foramen to supply the diploë, the walls of the lateral sinus, the dura mater, and the mastoid air cells.

The *princeps cervicis* (*descending branch of occipital*) *artery* is the largest branch of the occipital artery. It is a descending branch, running down the back of the neck between the splenius and the complexus (*semispinalis capitis*) muscles. It divides into a superficial and a deep branch. The *superficial branch* pierces the splenius and runs between it and the trapezius, supplying these muscles and anastomosing with the superficial cervical (*ascending branch of transverse cervical*) artery, one of the terminal branches of the transverse cervical; the *deep branch* descends between the complexus (*semispinalis capitis*) and semispinalis cervicis, supplies these muscles, and anastomoses with branches of the vertebral and with the deep cervical branch of the superior intercostal artery (*costo-cervical trunk*). The anastomoses between the occipital, vertebral, superior intercostal (*costo-cervical trunk*), and transverse cervical arteries play an important part in providing collateral circulation after ligation of either the common carotid or the subclavian artery.

Communicating branches run between the recti and the obliquus capitis superior and inferior muscles to anastomose with branches of the vertebral artery.

The *terminal branches* pass laterally and medially upward in the superficial fascia of the occipital region of the scalp to supply the scalp and the pericranium, and are known as external and internal. They anastomose with branches of the occipital artery of the opposite side and with the posterior auricular, and the superficial temporal arteries. The *internal branch* gives off a *meningeal twig* which passes through the parietal foramen.

The **occipital vein** accompanies the third portion of the occipital artery; it communicates with the lateral sinus through the mastoid foramen, and with the diploic veins, piercing the trapezius muscle with the occipital artery. It enters the occipital triangle and terminates in the deep cervical vein, or it may bifurcate, one subdivision emptying into the posterior jugular vein and the other into the deep cervical vein. The *deep cervical vein* accompanies first the deep branch of the princeps cervicis (*descending branch of the occipital*) artery, then the deep cervical artery, and, passing between the transverse process of the seventh cervical vertebra and the neck of the first rib, empties either into the innominate or the vertebral vein.

The **posterior auricular artery,** the last posterior branch of the external carotid, is smaller than the occipital artery, and arises just above the posterior belly of the digastric muscle. It ascends obliquely upward and backward in the parotid gland to the furrow between the auricles of the ear and the mastoid process of the temporal bone, passing below the facial nerve and over the spinal accessory (*accessory*) nerve. Immediately above the mastoid process it divides into two branches, an anterior auricular branch which passes forward and anastomoses with the posterior division of the temporal artery, and a posterior occipital branch which anastomoses with the occipital artery.

The Branches of the posterior auricular artery are the parotid, muscular, stylo-mastoid, auricular and occipital.

The *parotid branches* supply the lower parotid gland, anastomosing with other arteries distributed to the gland.

The *muscular branches* supply the digastric, stylo-hyoid, sterno-mastoid, and retrahens aurem (*auricularis posterior*) muscles.

The *stylo-mastoid branch* enters the stylo-mastoid foramen of the temporal bone, and supplies the tympanum, the mastoid cells, and the semicircular canals. In the fetus a branch of the stylo-mastoid artery, together with the tympanic branch from the internal maxillary artery, forms a vascular circle around the circumference of the tympanic membrane; from this circle smaller vessels are given off, which ramify upon the membrane. From the aqueduct of Fallopius (*facial canal*) it sends *meatal branches* to the external auditory meatus; *mastoid branches* to the mastoid cells and mastoid antrum; *stapedic branches* to the stapedius muscle; *tympanic branches* to the tympanum, forming the anastomotic circle in the fetus; *vestibular branches* to the vestibule and semicircular canals, and a final *terminal twig,* which accompanies the greater superficial petrosal nerve through the hiatus Fallopii (*hiatus of facial canal*) and anastomoses with the petrosal branch of the middle meningeal artery.

The *anterior auricular branch* supplies the back of the auricle, and anastomoses with the posterior temporal (*parietal*) and auricular (*anterior auricular*)

branches of the superficial temporal artery; some of its branches perforate the cartilage of the auricle to supply its anterior surface.

The *occipital branch* crosses the insertion of the sterno-mastoid muscle, supplies the structures over the mastoid process, and anastomoses with the occipital artery.

The **posterior auricular vein** is a large vein accompanying the terminal portion of the posterior auricular artery and joining the posterior division of the temporo-maxillary (*posterior facial*) vein to form the external jugular vein.

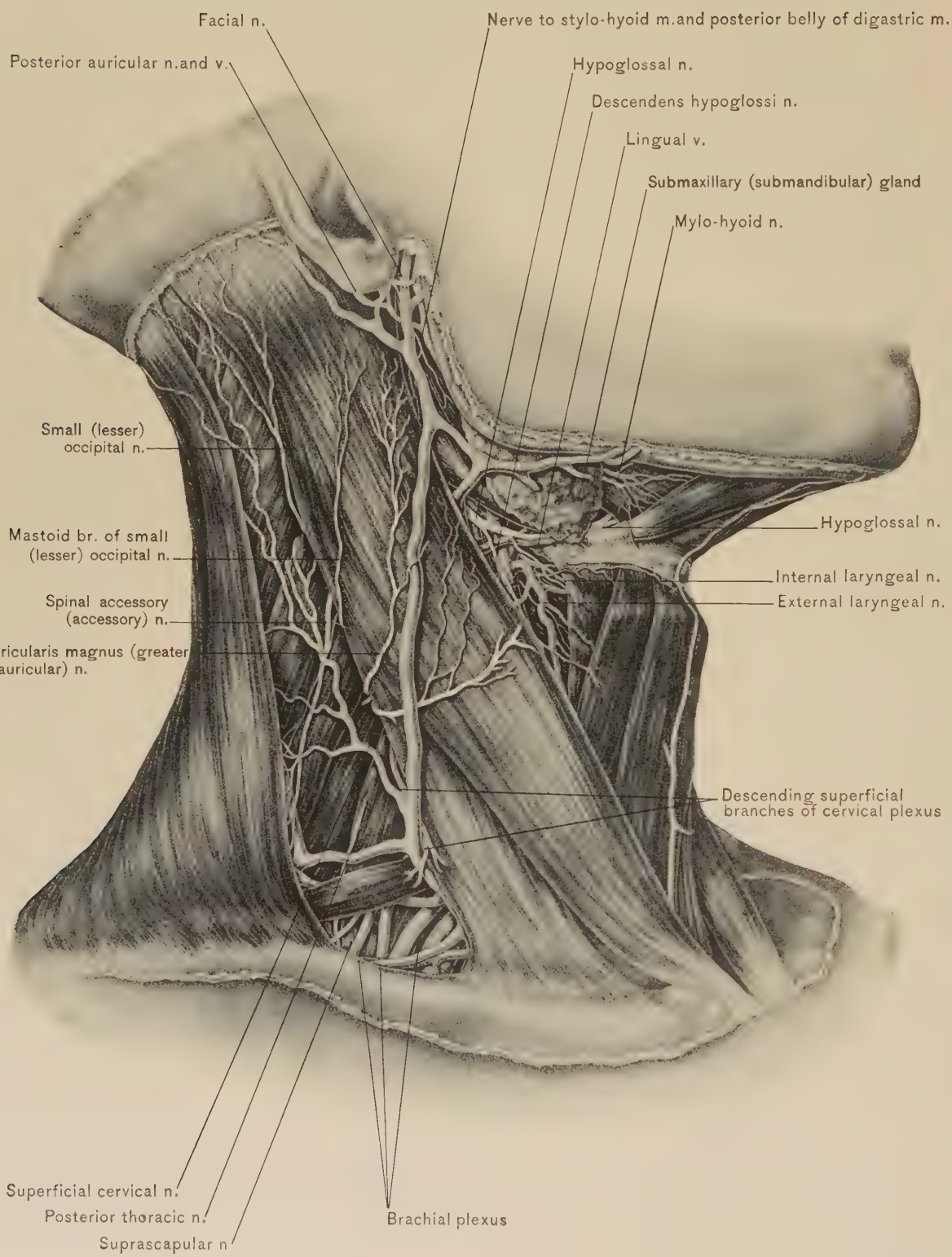
The posterior auricular nerve runs close to the posterior auricular artery, and is the first branch given off from the facial after its exit from the stylo-mastoid foramen. It ascends in front of the mastoid process, where it communicates with the great auricular nerve and the auricular branch of the vagus nerve. Between the mastoid process and the external auditory meatus it divides into two branches: an *auricular branch* which supplies the retrahens aurem (*auricularis posterior*) and the small muscles on the back of the auricle, and an *occipital branch*, the larger of the two, which passes along the superior curved (*superior nuchal*) line of the occipital bone, supplying the occipital (*occipital belly of epicranius*) muscle and communicating with the small occipital nerve.

The **ascending pharyngeal artery,** the smallest branch of the external carotid artery, is a long, slender vessel which arises from the back part of the external carotid about twelve millimeters (one-half inch) above the bifurcation of the common carotid artery. Sometimes, however, it arises from the common carotid artery. It is situated deep in the neck, in relation with the internal carotid artery, and lies upon the rectus capitis anterior major (*longus capitis*) muscle. It ascends between the internal carotid artery and the side of the pharynx, and beneath the stylo-pharyngeus muscle and the glosso-pharyngeal nerve, to the base of the skull; here it enters the pharynx above the superior constrictor muscle, to end in the soft palate. It gives off prevertebral, pharyngeal, meningeal, palatine, and tympanic branches.

The *prevertebral branches* are small vessels which pass lateralward to supply the rectus capitis anterior major (*longus capitis*) and minor (*rectus capitis anterior*) muscles, the sympathetic, vagus, and hypoglossal nerves, and the deep cervical chain of lymph glands. They anastomose with branches of the ascending cervical artery.

The *pharyngeal branches*, three or four in number, supply the upper and middle constrictor muscles, the mucous membrane of the pharynx, and the stylo-pharyngeus muscle. The largest of these branches, the *palatine*, enters the pharynx above the superior constrictor muscle, and terminates in the soft palate, the

PLATE CCLIII.



SUPERFICIAL STRUCTURES OF NECK.

Eustachian (*auditory*) tube and the tonsil; it takes the place of the ascending palatine branch of the facial (*external maxillary*) artery when this vessel is small.

The *meningeal branches* are several small vessels which enter the cranial cavity through the jugular foramen, in company with the internal jugular vein, and through the anterior condyloid (*hypoglossal canal*) and middle lacerated (*foramen lacerum*) foramina to supply the dura mater.

The *inferior tympanic branch* traverses the tympanic canaliculus, together with the tympanic branch of the glosso-pharyngeal nerve, enters the tympanum, anastomoses with the other tympanic arteries, and supplies the adjacent structures.

The **descending pharyngeal** (**pharyngeal**) **veins** arise in a minute plexus on the lateral surface of the pharynx, and after receving meningeal branches, the veins from the soft palate and the Eustachain (*auditory*) tube, and the Vidian vein (*vein of pterygoid canal*), terminate in the internal jugular vein; occasionally they empty into the facial (*anterior facial*) vein.

The **internal maxillary and temporal arteries** are described with the Dissection of the Pterygo-maxillary Region and the Face, respectively (see Vol. I).

The **Submaxillary** (**Submandibular**) **Triangle** (continued).—

The **digastric muscle** (Plate CCLIII) consists of two fleshy bellies united by an intervening tendon. The *posterior belly*, the longer of the two, *arises* from the digastric fossa (*mastoid notch*), which lies to the medial side of the base of the mastoid process of the temporal bone; the *anterior belly arises* from the depression on the deep surface of the mandible at the side of the symphysis. The fibers of the posterior belly are directed inferiorly, anteriorly, and medially; those of the anterior belly are directed inferiorly and posteriorly to the intervening tendon, which pierces the stylo-hyoid muscle, and is connected to the side of the body of the hyoid bone by a process of the deep cervical fascia lined with a synovial membrane. A broad aponeurotic expansion, the *suprahyoid aponeurosis*, is given off on each side from the tendon of the digastric muscle, and is attached to the body and greater cornu of the hyoid bone and to the aponeurotic expansion of the opposite side, so that the interval between the anterior bellies of the digastric muscles is occupied by this expansion. The posterior belly passes over the sheath of the carotid vessels, the hypoglossal and spinal accessory (*accessory*) nerves, and beneath the sterno-mastoid and trachelo-mastoid (*longissimus capitis*) muscles. The occipital artery passes superiorly and posteriorly along the

inferior border of the posterior belly. The digastric muscle is subject to numerous variations: the posterior belly may arise partly or altogether from the styloid process, or it may be connected by a slip to the middle or inferior constrictor muscles of the pharynx. The anterior belly often is double, or it may be connected by slips to the mandible or the mylo-hyoid muscle and join a slip on the opposite side. The anterior belly occasionally is absent.

Nerve Supply.—The posterior belly of the digastric muscle is supplied by the digastric branch of the facial nerve; the anterior belly, by the mylo-hyoid nerve from the inferior dental (*inferior alveolar*) branch of the mandibular division of the trigeminal, or fifth, nerve.

Blood Supply.—From muscular branches of the facial (*external maxillary*), occipital, and posterior auricular arteries.

Action.—It depresses the mandible and assists in opening the mouth. With the mandible fixed, the two bellies acting together raise the hyoid bone, as in deglutition.

The **stylo-hyoid muscle** is a slender muscle, lying in front of and above the posterior belly of the digastric. It *arises* from the middle of the lateral surface of the styloid process of the temporal bone, passing downward and forward to be *inserted* into the lateral surface of the body of the hyoid bone, at its junction with the greater cornu. It is pierced near its insertion by the tendon of the digastric. The stylo-hyoid muscle sometimes is absent.

Nerve Supply.—From a branch of the digastric branch of the facial nerve.

Blood Supply.—From the muscular twigs of the facial (*external maxillary*), occipital, and posterior auricular arteries.

Action.—It raises and draws the hyoid bone backward, thus preventing the return of food into the pharynx during deglutition.

The **submaxillary** (**submandibular**) **gland,** one of the three salivary glands, is situated largely in the submaxillary triangle and extends upward under the body of the mandible as far as the attachment of the mylo-hyoid muscle, around the posterior border of which it sends a deep prolongation which extends for a variable distance along the floor of the mouth. It weighs from seven to ten grams. It consists of a large superficial portion and a smaller deep portion. The superficial portion of the gland is covered by the skin, superficial fascia, the platysma muscle, the inframandibular (*cervical*) branches of the facial nerve, the superficial layer of the deep fascia, the facial (*anterior facial*) vein, some lymph glands, and the body of the mandible; it rests upon the mylo-hyoid, hyoglossus, stylo-glossus muscles, the facial (*external maxillary*) artery, submental artery, mylo-hyoid artery and nerve, and the hypoglossal nerve and lingual vein; in front of it is the anterior belly of the digastric muscle; behind it is the stylo-

mandibular ligament, which separates it from the parotid gland. Its deep surface contains a groove for the facial (*external maxillary*) artery. The deep portion and the duct of the gland, the submaxillary or Wharton's (*submandibular*) duct, which dip under the posterior border of the mylo-hyoid muscle, are described at p. 537.

Blood Supply.—From branches of the facial (*external maxillary*) and lingual arteries.

Nerve Supply.—From branches of the submaxillary ganglion, through which it receives filaments from the lingual and chorda tympani nerves. It also receives branches from the mylo-hyoid nerve and from the sympathetic plexus around the facial (*external maxillary*) artery.

Dissection.—Reflect the submaxillary gland upward without dividing the facial (*anterior facial*) vein, which runs over the gland, or the facial (*external maxillary*) and submental arteries, which are beneath it. Divide the submaxillary (*glandular*) branches of the facial (*external maxillary*) artery, which supply the gland, and expose a portion of the facial (*external maxillary*) artery and its inframandibular branches, the mylo-hyoid artery and nerve, a part of the hypoglossal nerve and lingual vein, the mylo-hyoid hyoglossus, and stylo-glossus muscles.

The cervical portion of the facial (*external maxillary*) artery and its submaxillary (*glandular*), submental, ascending palatine, and tonsillar branches have been described at p. 517.

The **mylo-hyoid nerve,** a branch of the inferior dental (*inferior alveolar*) nerve, may be seen emerging from between the mandible and the internal pterygoid muscle. It runs forward with the submental artery upon the mylo-hyoid muscle, to terminate in the anterior belly of the digastric muscle, supplying the mylo-hyoid and the anterior belly of the digastric muscle.

The **mylo-hyoid artery** accompanies the mylo-hyoid nerve between the internal pterygoid muscle and the mandible, and anastomoses with the submental and dorsalis linguæ arteries.

The **hypoglossal nerve,** the motor nerve of the muscles of the tongue, both intrinsic and extrinsic, except the glosso-palatinus, is the twelfth, or last, of the cranial nerves. It leaves the cranial cavity at the anterior condyloid foramen (*hypoglossal canal*), and descends almost vertically toward the angle of the mandible. At first it lies deep beneath the internal jugular vein and the internal carotid artery, and is intimately connected with the ganglion of the trunk (*ganglion nodosum*) of the vagus nerve. It then passes forward between the internal jugular vein and the internal carotid artery and beneath the posterior belly of the digastric muscle, at the lower border of which it becomes more superficial and enters the superior carotid triangle. It next passes over the internal carotid and curves around the occipital artery, at its origin from the external carotid artery;

thence it continues forward over the external carotid and facial (*external maxillary*) arteries, and near the greater cornu of the hyoid bone, over the superior laryngeal nerve, the middle constrictor muscle of the pharynx, and the hyoglossus muscle, forming a loop the convexity of which is directed downward and lateralward. At the anterior border of the hyo-glossus muscle it communicates with the lingual nerve. It passes beneath the tendon of the digastric, the stylohyoid, and the mylo-hyoid muscle. Running beneath the stylo-hyoid and the posterior part of the tendon of the digastric muscle, it lies in the submaxillary triangle upon the hyoglossus muscle, and beneath the submaxillary gland. Here it forms the base of the lingual, or Lesser's, triangle, and lies above the lingual vein. It supplies all of the extrinsic muscles of the tongue. The descendens hypoglossi nerve, which supplies the thyro-hyoid, the omo-hyoid, sterno-hyoid, and sternothyroid muscles is only an apparent branch of the twelfth, since these fibers have their origin from the cervical plexus. The branch to the thyro-hyoid muscle is given off near the tip of the greater cornu of the hyoid bone, and passes obliquely downward and forward to reach the superficial surface of that muscle.

Paralysis of one hypoglossal nerve causes wasting and flabbiness of the corresponding half of the tongue; when the tongue is protruded, the tip of the organ is carried toward the paralyzed side. Involvement of this nerve is seen in bulbar palsy. It is used at times for nerve anastomosis, although, if available, it is better to use the spinal accessory (*accessory*). It can be very easily exposed by an incision similar to that used for ligating the second portion of the lingual artery.

Dissection.—In completing the dissection of the submaxillary triangle the anterior belly of the digastric muscle should be detached from the mandible and displaced downward, in order to expose the mylo-hyoid, the muscle which forms the greater part of the floor of the triangle and of the mouth.

The **mylo-hyoid muscle** (Plate CCLIII) is a triangularly shaped muscle, with its base at the mandible and its apex at the hyoid bone; it unites along the midline with the mylo-hyoid muscle of the opposite side. It is sometimes termed the diaphragm of the mouth, or the upper diaphragm. It *arises* from the mylo-hyoid ridge, or internal oblique line, of the mandible, its origin extending from the symphysis as far back as the last molar tooth. The posterior fibers are *inserted* into the body of the hyoid bone; the intermediate and anterior fibers into the median fibrous raphe, where they join the fibers of the opposite muscle. In relation with its lower, or cutaneous, surface are: the anterior belly of the digastric muscle, the suprahyoid aponeurosis, the mylo-hyoid nerve and artery, the submental vessels, and the submaxillary gland. The duct of the submaxillary gland winds around its free posterior border. In relation with its deep, or buccal, surface are: the geniohyoid muscle, part of the hyoglossus and stylo-glossus muscles, the deep part of

the submaxillary gland, the submaxillary, or Wharton's, duct, the hypoglossal and lingual nerves, the submaxillary ganglion, the sublingual gland, the ranine (*profunda linguæ*) and sublingual arteries, and the mucous membrane of the mouth.

Nerve Supply.—From the mylo-hyoid branch of the inferior dental (*inferior alveolar*) nerve.

Blood Supply.—From the submental branch of the facial (*external maxillary*) artery.

Action.—When both muscles act conjointly from their point of origin they elevate the hyoid bone, the larynx, and the floor of the mouth preparatory to swallowing; when acting from their hyoid attachment they assist in depressing the mandible and in opening the mouth.

Dissection.—Divide the facial vessels immediately below the mandible, and displace them upward with the superficial part of the submaxillary gland, leaving *in situ* the deep part of the gland which turns beneath the mylo-hyoid muscle and has the submaxillary ganglion in contact with it. Divide the small vessels and nerves on the cutaneous surface of the mylo-hyoid muscle, detaching it from the mandible and the mylo-hyoid muscle of the opposite side, and displace it downward. This exposes the structures in relation with the upper surface of the mylo-hyoid muscle.

The **genio-hyoid muscle** is a slender muscle which *arises* from the lower of the two lateral genial tubercles (*mental spines*) on the inner aspect of the symphysis of the mandible, and is *inserted* into the middle of the anterior surface of the body of the hyoid bone. It is covered by the mylo-hyoid muscle, rests upon the genio-glossus muscle, and medially, against the genio-hyoid muscle of the opposite side.

Nerve Supply.—From the hypoglossal nerve.

Blood Supply.—From the lingual artery.

Action.—It raises and advances the hyoid bone; when the mouth is closed, acting in the reverse direction, it assists in depressing the mandible and in opening the mouth. It may be inseparable from the genio-hyoid muscle of the other side.

Dissection.—The mandible should be sawed through at two points: immediately in advance of the angle, and at the symphysis; the intervening portion, carrying with it the mucous membrane of the mouth, should be displaced upward, and fastened with hooks or with a stitch. The tongue should next be drawn out of the mouth, its tip fastened to the nose, and the hyoid bone should be drawn downward and also fixed by means of hooks, thus putting the muscular fibers of the tongue on the stretch. All the fat and connective tissue having been removed, the following structures should be carefully examined: the hyoglossus, stylo-glossus, and genio-glossus muscles, the lingual vein, the hypoglossal nerve, the lingual nerve, the submaxillary ganglion, the submaxillary, or Wharton's,

(*submandibular*) duct, the deep portion of the submaxillary gland, the sublingual gland, the ranine (*profunda linguæ*) and sublingual arteries.

The **hyo-glossus muscle** (Plates CCLIV; CCLV) is a thin, flat, square-shaped muscle, *arising* from the side of the body of the hyoid bone and from its greater and lesser cornua. It is *inserted* into the posterior half of the side of the tongue between the stylo-glossus and lingual muscles. Its fibers ascend almost perpendicularly from their origin to their insertion, and mingle with the fibers of the glosso-palatinus and stylo-glossus muscles. The fibers arising from the body of the hyoid bone, termed the *basio-glossus*, pass upward and backward, and overlap those which arise from the greater cornu, termed the *kerato-glossus*, which are directed obliquely forward. The fibers arising from the lesser cornu are termed the *chondro-glossus*, and are separated from the remainder of the muscle by a few fibers of the genio-glossus muscle; they are covered by the fibers arising from the body of the hyoid bone.

Nerve Supply.—From the hypoglossal nerve.

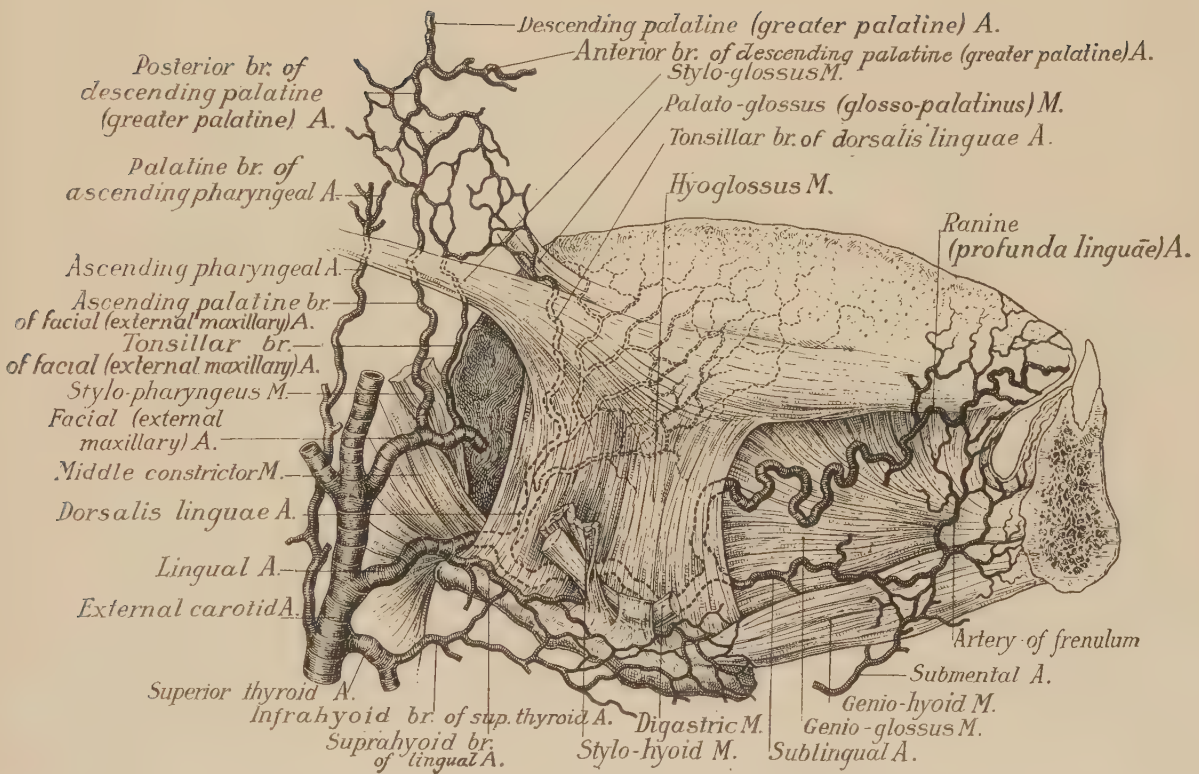
Blood Supply.—From the lingual artery.

Action.—It draws the side of the tongue downward, and when the tongue is protruded it draws it back into the mouth.

Relations of the Hyo-glossus Muscle.—Upon the lateral surface of the muscle are the hypoglossal nerve and the small branch which ascends to the stylo-glossus muscle, the lingual nerve, the loop of communication between the lingual and hypoglossal nerves, the submaxillary ganglion, the submaxillary gland, the submaxillary, or Wharton's, duct, the hyoid branch of the lingual artery, the lingual vein, the sublingual gland, the posterior belly of the digastric, the stylo-hyoid, stylo-glossus, and myo-hyoid muscles. Its deep surface is in contact with the genio-glossus, the lingualis, the middle constrictor muscle of the pharynx, part of the origin of the superior constrictor muscle, the lingual artery, the glosso-pharyngeal nerve, and the stylo-hyoid ligament. At the posterior border of the hyo-glossus muscle are the lingual artery, the glosso-pharyngeal nerve, and the stylo-hyoid ligament passing beneath the muscle. At the anterior border are the loop of communication between the lingual and hypoglossal nerves, the branches of which can be traced to the under surface of the tongue, and the ranine (*profunda linguæ*) artery, emerging from beneath the anterior border of the hyo-glossus muscle.

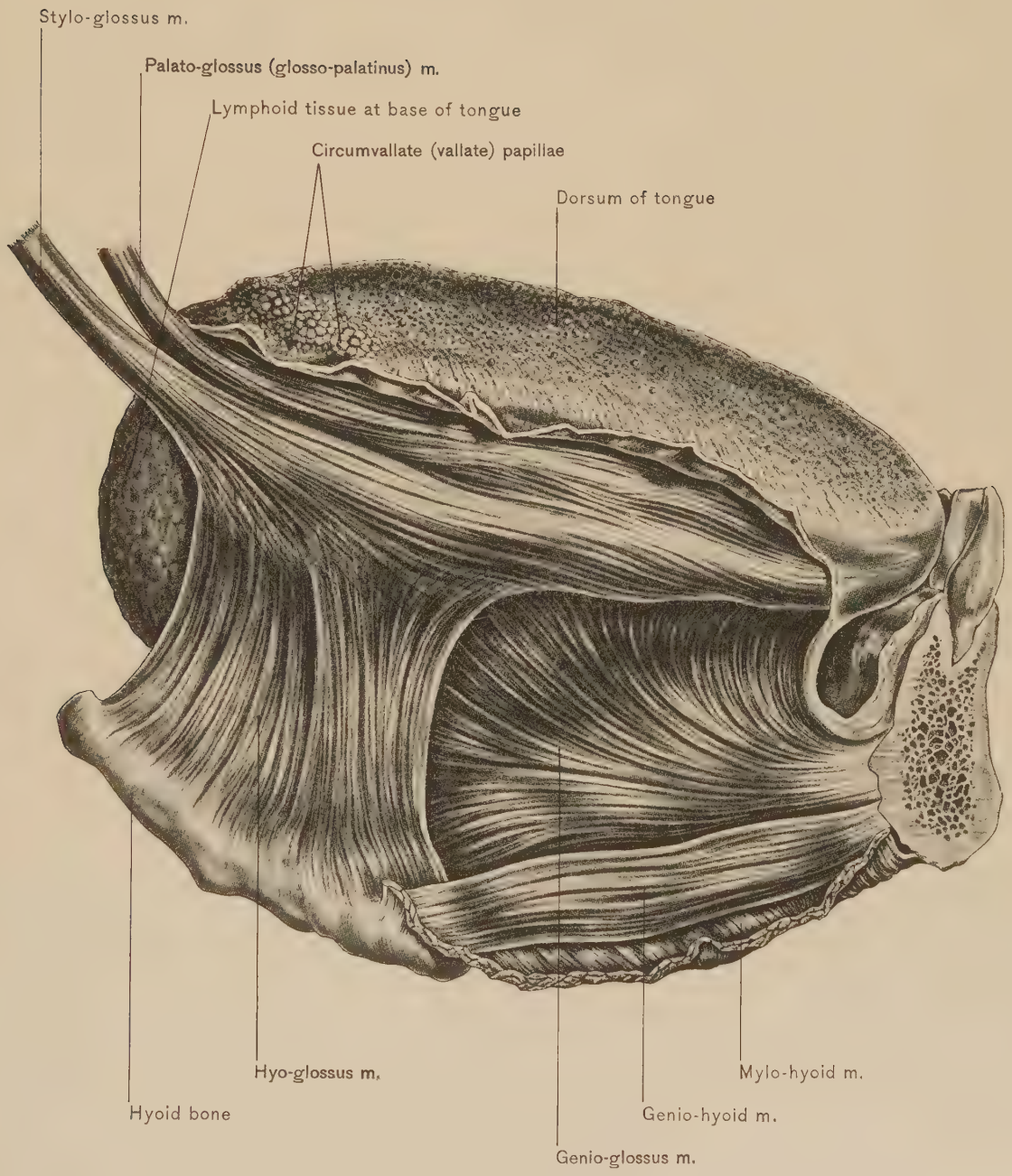
The **stylo-glossus muscle,** the smallest of the three muscles which arise from the styloid process, *arises* from the anterior and lateral sides of that process near its apex, and from the stylo-mandibular ligament. Its fibers pass downward and forward, and then run almost horizontally to be *inserted* along the side of the tongue, superficial to the hyo-glossus muscle, and as far forward as the tip of that

PLATE CCLIV.



ARTERIES OF TONGUE AND TONSIL.

PLATE CCLV.



EXTRINSIC MUSCLES OF TONGUE.

organ; they blend with the fibers of the lingualis inferior (*longitudinalis inferior*) muscle. Beneath the mandible the stylo-glossus muscle is crossed by the lingual nerve.

NERVE SUPPLY.—From the hypoglossal nerve.

BLOOD SUPPLY.—From the muscular branches of the facial (*external maxillary*) artery.

ACTION.—When both muscles act together they raise the back of the tongue toward the roof of the mouth. When the tongue is protruded, they draw it back into the mouth. They also draw the sides of the tongue upward, thus helping to make it transversely concave.

The **genio-glossus muscle,** the largest of the muscles of the tongue, is triangular in shape, with its apex attached to the mandible, and its base to the tongue and the hyoid bone. It *arises* from the superior genial tubercle (*mental spine*) on the inner aspect of the symphysis of the mandible, immediately above the genio-hyoid muscle. The fibers diverge from their origin, the inferior fibers passing downward to be *inserted* into the body of the hyoid bone, and over this passing as far backward as the base of the epiglottis; the middle fibers, into the side of the pharynx, and the superior fibers, into the tongue from the root to the tip. In relation with the external surface of the muscle are the stylo-glossus, hyoglossus, and lingual muscles, the lingual artery, the hypoglossal and lingual nerves, the sublingual gland, and the submaxillary, or Wharton's, duct. It is separated from the genio-glossus muscle of the opposite side by the *septum linguæ,* a fibrous septum which extends through the middle of the tongue. Below it is the genio-hyoid muscle.

NERVE SUPPLY.—From the hypoglossal nerve.

BLOOD SUPPLY.—From the lingual artery.

ACTION.—By the simultaneous action of all the fibers of the muscle attached to the tongue that organ is depressed and its upper surface grooved. The fibers inserted near the base of the tongue protrude it, while those attached near the tip retract it after it has been protruded. The inferior fibers aid the genio-hyoid and the anterior belly of the digastric muscle in pulling the hyoid bone upward and forward; acting from below, they tend to depress the chin. Contraction of this muscle in epileptic convulsions causes the tongue to protrude, and as a result it may be bitten. In certain fractures of the mandible, as well as in some operations near the tongue and the floor of the mouth in which the origin of this muscle is detached, the tongue has a tendency to fall backward over the superior opening of the larynx, and respiration may be embarrassed. During anesthetization the base of the tongue at times falls backward, and breathing becomes labored; by carrying the angles of the mandible forward, the genio-glossus muscles

are made to pull the tongue forward, and thus relieve the difficulty. If the genio-glossus muscle of one side is paralyzed and the patient is asked to protrude the tongue, the sound muscle pulls its own side of the base of the tongue forward, whereas, the other side is not acted upon, and the tip of the tongue will consequently protrude toward the paralyzed side.

The **lingual vein** is formed by the union of the sublingual, also known as the *ranine* vein, and the deep lingual veins, the venæ comites of the lingual artery. It arises near the tip of the tongue, and accompanies the hypoglossal nerve over the lateral surface of the hyoglossus muscle, which separates it from the lingual artery. It passes beneath the stylo-hyoid and posterior belly of the digastric muscles, and empties into the internal jugular, or by a common trunk into the facial (*anterior facial*) vein. When the lingual empties into the internal jugular vein, it crosses the external carotid artery at about the level of the greater cornu of the hyoid bone.

The hypoglossal nerve.—The course of this nerve to the point where it passes beneath the posterior border of the mylo-hyoid muscle has been described at p. 527. In the submaxillary triangle it lies on the hyo-glossus muscle, accompanied by the lingual vein, and communicates with the lingual nerve at the anterior border of that muscle, from which point it continues forward to the tip of the tongue in the substance of the genio-glossus muscle.

The **lingual nerve** is a branch of the mandibular division of the trigeminal nerve, and for some little distance from its origin it lies in the pterygo-maxillary region (*infratemporal fossa*). It is the smaller of the terminal divisions of the mandibular nerve. (See Dissection of the Pterygo-maxillary Region (Infratemporal fossa), Vol. I.) Passing between the ramus of the mandible and the internal pterygoid muscle it leaves the pterygo-maxillary region (*infratemporal fossa*), inclines forward along the side of the tongue, and runs upon the superior constrictor muscle of the pharynx and between the stylo-glossus muscle and the deep portion of the submaxillary gland. It next crosses the upper part of the hyoglossus muscle and the submaxillary, or Wharton's, duct, whence it passes between the mylo-hyoid muscle and the mucous membrane of the floor of the mouth along the side of the tongue to its tip. Two or more branches connect the lingual nerve with the submaxillary ganglion near the root of the tongue, while near the anterior border of the hyoglossus muscle it forms a loop with the hypoglossal nerve.

It supplies the mucous membrane of the mouth, the lower gums, and the sublingual and submaxillary glands, and gives off branches which ascend through the muscular substance of the tongue to the filiform and fungiform papillæ. The branches to the sublingual and submaxillary glands contain secretomotor fibers,

which, when stimulated, increase the secretion of these glands. The lingual is the common sensory nerve of the tongue, and contains taste fibers for the anterior two-thirds of that organ.

Unilateral operations on the tongue may be done under local block anæsthesia by exposing the nerve through a small incision between the base of the tongue and the inner side of the mandible. The nerve can be brought into the wound by passing an aneurysm needle from within outward.

The **submaxillary ganglion** is the smallest of the sympathetic ganglia connected with the trigeminal nerve. It is situated upon the hyoglossus muscle, between the lingual nerve and the deep portion of the submaxillary gland and beneath the posterior border of the mylo-hyoid muscle. It appears to be suspended from the lingual nerve by two small filaments. Like the other ganglia of the head, it is connected with the branches of the trigeminal nerve and receives filaments of communication of three kinds: motor, sensory, and sympathetic. Its motor root arises from the facial nerve through the chorda tympani; the sensory branches are derived from the lingual nerve; its connection with the cervical sympathetic is through a branch which comes from the sympathetic plexus around the facial (*external maxillary*) artery. Its branches of distribution, five or six in number, supply the mucous membrane of the floor of the mouth and the submaxillary gland and its duct.

The submaxillary (submandibular), or Wharton's, duct, is about five centimeters (two inches) long, and has its origin in the deep portion of the submaxillary gland. It winds around the posterior, or free border, of the mylo-hyoid muscle, then lies on the hyo-glossus muscle, between the hypoglossal and lingual nerves, under cover of the mylo-hyoid muscle; thence it passes forward over the genio-glossus muscle and beneath the lingual nerve and the sublingual gland, terminating in a constricted opening, situated on a small papilla in the floor of the mouth at the side of the lingual frenulum. Near its termination it is joined by one of the ducts of the sublingual gland, the duct of Bartholin (*greater sublingual duct*). The lingual nerve, soon after leaving the gland, passes under the duct from without inward. The sublingual artery runs alongside the duct and a plexus of veins surrounds it.

The submaxillary (submandibular) gland.—The deep portion of the submaxillary gland turns forward around the posterior, or free border, of the mylo-hyoid muscle, lying between it and the hyo-glossus muscle, and extends along the floor of the mouth.

The **sublingual gland,** the smallest of the three salivary glands, weighing from three to four grams, lies upon the mylo-hyoid muscle beneath the mucous membrane of the floor of the mouth at the side of the lingual frenum, where it

produces an oblong prominence. It differs from the parotid and submaxillary glands in that it has no capsule. It is in contact, on its medial side, with the hyo-glossus, genio-glossus, and stylo-glossus muscles, the lingual nerve, and the duct of the submaxillary gland; laterally, with the sublingual fossa in the body of the mandible, and with the mylo-hyoid muscle; behind, with the deep portion of the submaxillary gland, and touching the other sublingual gland in the median plane. It measures about five centimeters (two inches) in its long diameter. Its ducts, or sublingual ducts, *ducti Rivini*, are from ten to twenty in number, and open separately on the ridge at each side of the lingual frenulum, with the exception of two or more which join to form the *greater sublingual duct*, or *duct of Bartholin*, which opens either near or into the submaxillary duct.

Blood Supply.—From the lingual and submental arteries.

Nerve Supply.—From the lingual, the chorda tympani, and the cervical sympathetic. The **lymphatics** of the duct pass to the submaxillary nodes.

Obstruction of the salivary ducts.—The duct of the submaxillary gland may become obstructed by a calculus, giving rise to a hard and painful swelling over the site of the duct, perceptible in the submaxillary triangle and through the floor of the mouth. The walls of the submaxillary duct are quite inelastic; this explains the intense pain associated with obstruction due to salivary calculus. Obstruction and dilatation of one of the several ducts opening at the side of the lingual frenum causes a cystic swelling, frequently called a *ranula*, although a ranula is now looked upon as a branchio-genetic cyst. Acute ranula is a collection in the sublingual bursa which is the space between the genio-glossus muscle and the mucous membrane.

Dissection.—Detach the hyo-glossus muscle from the hyoid bone and lift it up, when the structures in relation with the deep surface may be seen. These are: the horizontal portion and the commencement of the ascending portion of the lingual artery, part of the genio-glossus muscle, the lingual muscles, the origin of the middle constrictor muscle of the pharynx, the glosso-pharyngeal nerve, and the stylo-hyoid ligament.

The **horizontal, or second, portion of the lingual artery** rests upon the middle constrictor of the pharynx and the genio-glossus muscle, below the level of the glosso-pharyngeal nerve, and is covered by the tendon of the digastric, the stylo-hyoid, and the hyo-glossus muscles. From this portion the *dorsalis linguæ artery* is given off, which ascends to the base of the tongue to supply the mucous membrane back of the circumvallate papillæ, the tonsil, and the soft palate. It anastomoses with the dorsalis linguæ of the opposite side, but this anastomosis is so fine that severing the tongue accurately in the median line produces only slight bleeding.

The **ascending, or third, portion of the lingual artery** commences beneath the hyoglossus muscle. It rests upon the genio-glossus, and passes tortuously between the latter and the lingual muscles to the tip of the tongue, being covered only by the mucous membrane of the under surface of this organ. This portion gives off the sublingual artery and continues as the ranine (*profunda linguæ*).

The **ranine (profunda linguæ) artery,** the continuation of the lingual artery, passes to the tip of the tongue along the lateral side of the genio-glossus muscle, running between it and the lingual muscles, and is accompanied by the ranine (*comitans hypoglossi*) vein and the terminal portion of the lingual nerve. Near the tip of the tongue it anastomoses with the ranine (*profunda linguæ*) artery of the opposite side, and on its way supplies the adjacent muscles and mucous membrane.

The **sublingual artery,** smaller than the ranine (*profunda linguæ*), arises near the anterior border of the hyo-glossus muscle, and runs laterward and forward over the oral surface of the mylo-hyoid muscle to reach the sublingual gland. It supplies the sublingual gland, the mylo-hyoid muscle, the mucous membrane of the floor of the mouth, and the gums. It anatomoses with the opposite sublingual artery, and with the submental branch of the facial (*external maxillary*) artery, after having perforated the mylo-hyoid muscle.

The **artery of the frenum** is usually a branch of the sublingual artery. It is sometimes wounded in operating for "tongue tie," a condition, occuring in infants, in which the frenum of the tongue is abnormally short. The best way to divide the lingual frenum so as to avoid wounding the vessel, is to engage the frenum in the slot of a grooved director, by means of which the point of the tongue can be held up. The frenum is thus made tense, and is then easily nicked at its attachment to the mandible with a pair of blunt scissors.

The **stylo-pharyngeus muscle** is the longest of the three muscles *arising* from the medial side of the base of the styloid process. It passes downward and forward, and disappears between the middle and superior constrictor muscles of the pharynx. Some of its fibers join the palatino-pharyngeus (*pharyngo-palatinus*) muscle, to be *inserted* into the posterior border of the thyroid cartilage. The remaining fibers become connected with the fibers of the constrictor muscles of the pharynx. Running along its lateral side is the glosso-pharyngeal nerve. In order to reach the tongue, to which it is partly distributed, the nerve passes over the muscle, supplying it with twigs.

The **stylo-hyoid ligament** is a fibrous cord which passes from the tip of the styloid process to the lesser cornu of the hyoid bone. It may be seen lying near the anterior border of the stylo-pharyngeus muscle, and passing beneath the hyoglossus muscle to the lesser cornu of the hyoid bone. It is the continuation of the

styloid process; it may contain nodules of cartilage, and may be largely ossified, forming an unusually long styloid process and constituting the epihyal bone found in many animals.

Dissection.—Cut off the styloid process at its base and reflect it downward with the attached muscles and the stylo-hyoid ligament.

The glosso-pharyngeal nerve.—Running along the posterior border of the stylo-pharyngeus muscle, and crossing in front of it, is the glosso-pharyngeal, or ninth, nerve. It curves upon the side of the neck, with its convexity directed downward and backward, resembling in this respect the hypoglossal and superior laryngeal nerves. The principal landmark for finding this nerve is the stylo-pharyngeus muscle, around which it curves and beyond which it lies on the middle constrictor muscle of the pharynx. The terminal portion of the nerve lies beneath the hyoglossus muscle, where it divides into *two terminal lingual branches*, one supplying the mucous membrane covering the posterior third of the dorsum of the tongue, and the other, the mucous membrane of the side of the tongue, inosculating with the lingual nerve. The glosso-pharyngeal is a mixed nerve, containing motor and sensory fibers, the latter including fibers of special sense (taste). The motor fibers supply the muscles of the pharynx; the sensory fibers supply the mucous membrane of the fauces, the palatine tonsil, and the pharynx; the fibers of *taste* are distributed to the base of the tongue and the fauces.

It leaves the cranial cavity by way of the middle compartment of the jugular foramen, clothed by a separate sheath of the dura mater, and lying in advance of, and a little medial to the vagus and spinal accessory (*accessory*) nerves. After leaving the foramen it descends between the internal jugular vein and the internal carotid artery, crosses obliquely over the latter vessel, and passes beneath the styloid process and the muscles arising therefrom, to reach the posterior border of the stylo-pharyngeus muscle, as previously described.

Upon the trunk of the nerve in the jugular foramen are two ganglia: an upper, the jugular (*superior*), and a lower, the petrous, the two being regarded as analogous to the ganglia on the posterior roots of the spinal nerves. The *jugular (superior) ganglion* is inconstant. When present, it is small and is usually considered to be a detached portion of the petrous ganglion. It lies in the upper part of the groove occupied by the glosso-pharyngeal nerve in its passage through the jugular foramen. At the *petrous ganglion*, or ganglion of Andersch, the glosso-pharyngeal nerve is connected with the vagus and the cervical sympathetic by communicating branches. The branches of the glosso-pharyngeal nerve, other than the terminal lingual and the communicating branches, are the tympanic, carotid, pharyngeal, muscular, and tonsillar.

The *tympanic branch*, or Jacobson's nerve, arises from the petrous ganglion, and is its most important branch. It passes to the medial wall of the tympanum through the tympanic canaliculus, a bony canal the orifice of which is situated upon the ridge of bone between the carotid canal and the jugular fossa, and ramifies upon the promontory of the tympanum, forming the *tympanic plexus*, which supplies branches to the oval windows and to the Eustachian (*auditory*) tube, and communicates with the carotid plexus and with the great and small superficial petrosal nerves.

The *carotid branches* surround the cervical portion of the internal carotid artery and communicate with branches of the vagus and the cervical sympathetic.

The *pharyngeal branches*, three or four in number, join branches from the vagus, superior laryngeal, and the cervical sympathetic nerves, and form the *pharyngeal plexus*, which supplies the pharynx.

The *muscular branch* supplies the stylo-pharyngeus muscle.

The *tonsillar branches* arise under the hyo-glossus muscle, and are distributed to, and around the tonsils, forming a plexus from which branches are distributed to the fauces and the soft palate.

The *communicating branches* arise from the petrous ganglion, as stated, and run to the superior cervical ganglion; to the auricular branch of the vagus, forming a loop; an inconstant branch to the ganglion of the root (*jugular ganglion*) of the vagus nerve, and one from the nerve just below the ganglion, to join the lingual branch of the facial nerve.

The *lingual branches* proceed from the end of the glosso-pharyngeal nerve, and are therefore its terminal filaments. They are distributed mainly to the circumvallate papillæ; some filaments supply the follicular glands of the tongue and the front of the epiglottis, and others inosculate around the foramen cecum with filaments of the same nerve of the opposite side.

The **Internal Carotid Artery**, the larger of the two terminal divisions of the common carotid, ascends perpendicularly by the side of the pharynx to the base of the skull, where it enters the carotid canal, in the petrous portion of the temporal bone. At first it lies lateral to the external carotid artery, and then posterior to it. At its origin it is more superficial than elsewhere, and lies in the superior carotid triangle; but as it ascends it lies deeper, passing beneath the parotid gland, the posterior belly of the digastric muscle, the styloid process, the stylo-pharyngeus and stylo-hyoid muscles. It is crossed by the hypoglossal and glosso-pharyngeal nerves, and the occipital and posterior auricular arteries. Laterally, it is in close relation with the internal jugular vein and the vagus nerve, and near the base of the skull with the glosso-pharyngeal, the hypoglossal, and spinal accessory (*accessory*) nerves; posteriorly, with the rectus capitis anterior major

(*longus capitis*) muscle, the superior ganglion of the cervical sympathetic, and the superior laryngeal nerve; medially, with the pharynx, the tonsil, and the ascending pharyngeal artery; anteriorly, it is covered by skin, fasciæ, the parotid gland, and the structures which pass between it and the external carotid artery: the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, and the stylo-hyoid ligament.

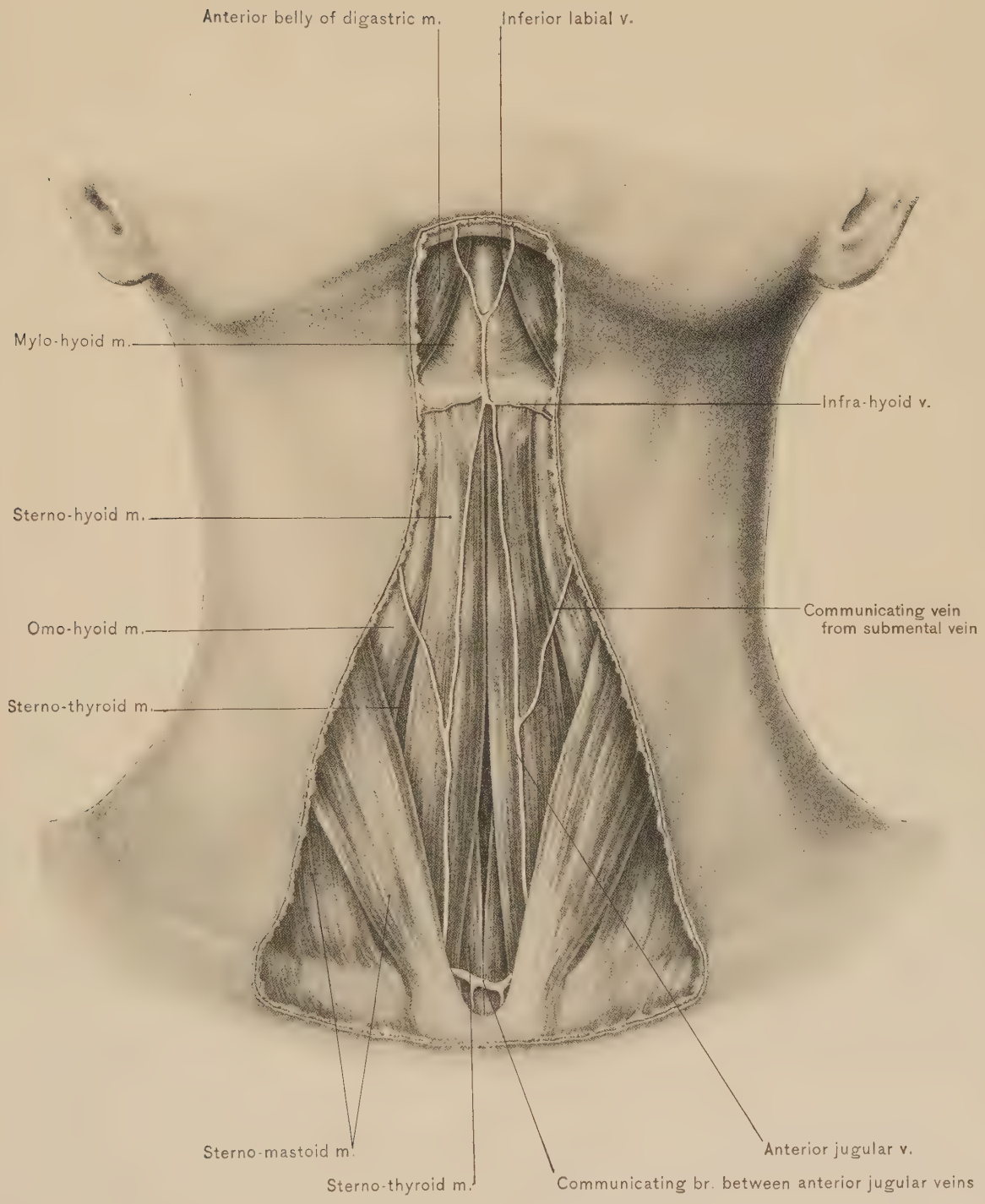
This vessel, because of the depth of its position, is not so frequently wounded as the external carotid. But it may be wounded during the operation of tonsillectomy when its position is unusually close to the tonsillar fossa. It is most easily ligated at its origin, the incision being the same as that for the terminal portion of the common carotid, or for the first portion of the external carotid.

Dissection.—Remove the deep fascia upon each side of the median line of the neck, and expose the anterior belly of the omo-hyoid, the sterno-hyoid, sterno-thyroid, and thyro-hyoid muscles (Plate CCLVI).

The **omo-hyoid muscle** consists of an anterior and a posterior belly, connected by an intervening tendon. The *anterior belly*, which is exposed in this dissection, *arises* at the tendon intervening between the two bellies of the muscle beneath the sterno-mastoid muscle and in front of the carotid sheath, on a level with the cricoid cartilage. It passes upward along the lateral border of the sterno-hyoid and over the sterno-thyroid and thyro-hyoid muscles, to be *inserted* into the lower border of the body of the hyoid bone lateral to the sterno-hyoid muscle. It lies beneath the superficial layer of the deep fascia and the sterno-mastoid muscle, and in front of the thyro-hyoid and sterno-thyroid muscles and the carotid sheath. It is sometimes absent or it may be double or it may blend with the adjacent sterno-hyoid muscle; occasionally, it receives an accessory slip from the manubrium sterni or sends one to the mandible.

The *posterior belly* of the muscle has already been seen crossing the posterior triangle just above the clavicle, and dividing it into the occipital and subclavian triangles. It *arises* from the superior border of the scapula, behind the suprascapular (*small scapular*) notch, and from the transverse ligament, and may have an additional origin from the upper surface of the middle third of the clavicle. It *terminates* in the tendon of the omo-hyoid muscle which crosses the carotid sheath. It is covered by the superficial layer of the deep fascia, the trapezius muscle, the clavicle, the subclavius and the sterno-mastoid muscles, the external jugular vein, and the descending superficial branches of the cervical plexus of nerves. It passes over the first digitation of the serratus magnus (*serratus anterior*) muscle and the third part of the subclavian artery, the transverse cervical and suprascapular (*transverse scapular*) arteries, the suprascapular nerve, the cervical trunks of the brachial plexus, the scaleni muscles, the preverte-

PLATE CCLVI.



SUPERFICIAL STRUCTURES NEAR MEDIAN LINE OF NECK.

bral fascia, and the carotid sheath. The intervening tendon is bound down by a process of the deep fascia, attached to the clavicle and the first rib.

Nerve Supply.—From the descendens hypoglossi and ansa hypoglossi nerves.

Action.—It draws the hyoid bone downward and assists in rendering tense the lower portion of the deep cervical fascia, thus diminishing the atmospheric pressure upon the large veins at the root of the neck and favoring the return circulation.

The **sterno-hyoid muscle** *arises* from the posterior surface of the upper part of the manubrium sterni, the posterior sterno-clavicular ligament, and the posterior surface of the medial extremity of the clavicle. Its fibers pass upward and medialward to be *inserted* into the lower border of the body of the hyoid bone. It sometimes has a tendinous intersection in its lower part. It lies beneath the skin and fasciæ and the anterior jugular vein, the sterno-mastoid muscle, the sterno-clavicular joint, and the manubrium sterni, and in front of the sterno-thyroid, thyro-hyoid, and crico-thyroid muscles, the thyroid and cricoid cartilages, the thyro-hyoid and crico-thyroid membranes, the pretracheal fascia, the trachea, the isthmus of the thyroid body, and the inferior thyroid veins.

Nerve Supply.—From the first three cervical nerves through the ansa hypoglossi.

Blood Supply.—From branches of the superior thyroid artery.

Action.—It draws the hyoid bone downward, as after swallowing. In labored respiration it elevates the sternum, being an accessory muscle of respiration.

The **sterno-thyroid muscle** is wider and shorter than the sterno-hyoid, beneath which it lies. It *arises* from the posterior surface of the upper part of the manubrium sterni and the cartilage of the first rib, below, and medial to the sterno-hyoid muscle. Its fibers pass upward and lateralward, and are *inserted* into the oblique line on the side of the thyroid cartilage, where it is continuous with the thyro-hyoid muscle. In the inferior carotid triangle the lateral border of the muscle partly overlaps the sheath of the common carotid artery. It lies beneath the skin and fasciæ, the manubrium sterni, the anterior jugular vein, the sterno-mastoid, sterno-hyoid, and the anterior belly of the omo-hyoid muscles, and in front of the thyroid and cricoid cartilages, the crico-thyroid muscle, the inferior constrictor muscle of the pharynx, the thyroid gland, the inferior thyroid veins, the pretracheal fascia, the trachea, the common carotid artery, and the left innominate vein. This muscle is sometimes absent or it may be double.

Nerve Supply.—From the first three cervical nerves through the ansa hypoglossi.

Action.—It draws the thyroid cartilage downward, as after swallowing, and assists the crico-thyroid muscle in rendering tense the vocal cords, by drawing the thyroid cartilage downward and forward. It is an accessory muscle of respiration.

The *interspace* between the medial borders of the sterno-hyoid muscles is wider at the sternum than at the hyoid bone, while the interspace between the medial margins of the sterno-thyroid muscles is wider above than at the sternum, thus forming a lozenge-shaped intermuscular space.

The **thyro-hyoid muscle,** apparently an extension of the sterno-thyroid muscle, *arises* from the oblique line on the side of the thyroid cartilage. Its fibers ascend and are *inserted* into the lower border of the body and the medial half of the greater cornu of the hyoid bone. The sterno-mastoid, sterno-hyoid, and the anterior belly of the omo-hyoid muscle pass over the lateral surface of the thyro-hyoid muscle; the superior laryngeal vessels and nerve, the thyro-hyoid membrane, the bursa, and the thyroid cartilage lie beneath it.

Nerve Supply.—From the descendens hypoglossi nerve.

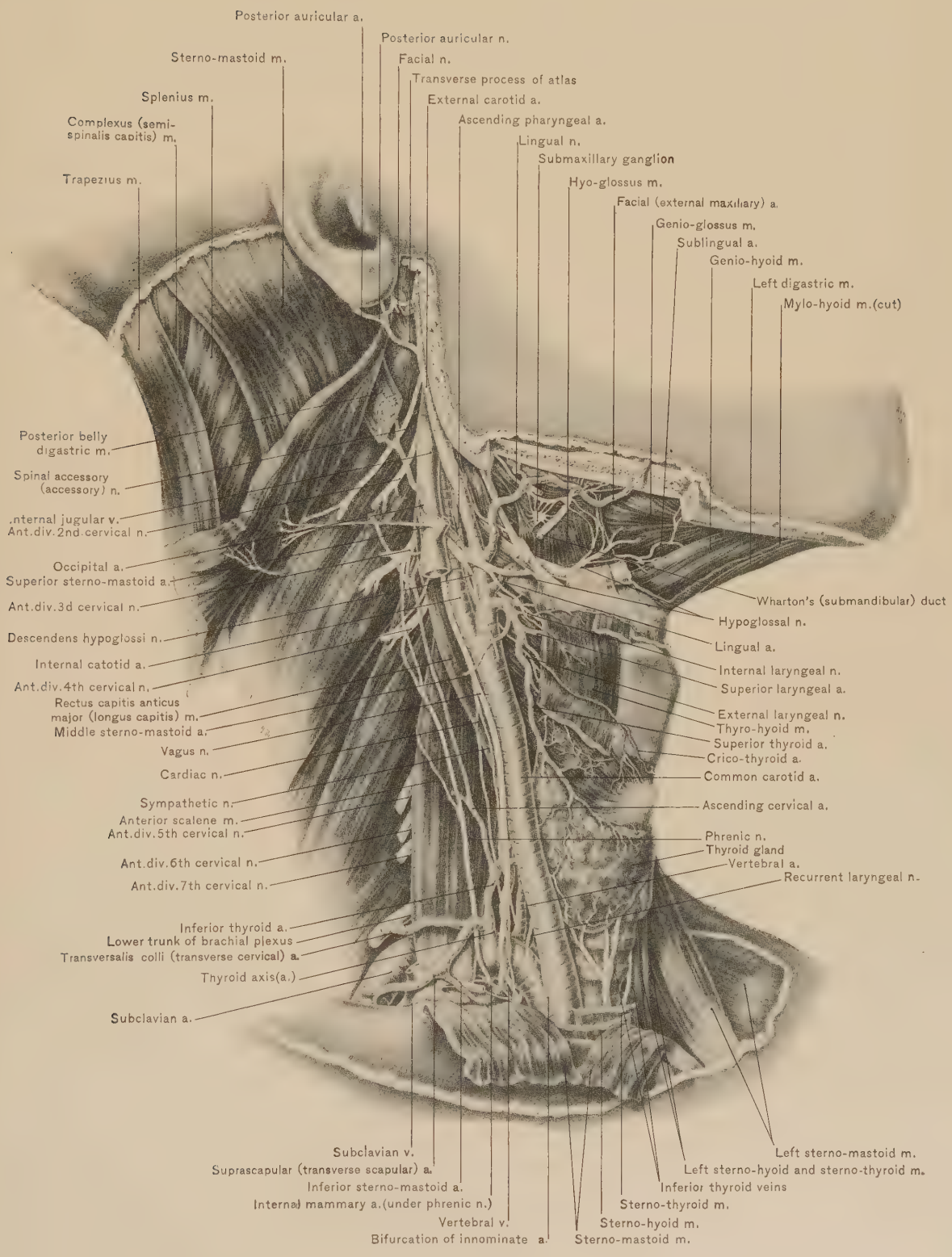
Blood Supply.—From the hyoid, the sterno-mastoid, and the crico-thyroid branches of the superior thyroid artery, and the hyoid branch of the lingual artery.

Action.—It raises the thyroid cartilage toward the hyoid bone preparatory to swallowing, and in conjunction with the sterno-thyroid muscle it depresses the hyoid bone and the larynx.

Dissection.—Divide the sterno-hyoid and sterno-thyroid muscles at their middle, and reflect them upward and downward. This exposes, from above downward: the thyro-hyoid membrane, pierced upon each side by the internal branch of the superior laryngeal nerve and the superior laryngeal artery; the thyroid cartilage; the crico-thyroid membrane, upon which are the crico-thyroid arteries; the cricoid cartilage, partly concealed by the crico-thyroid muscles; the first, and occasionally the second ring of the trachea; the thyroid gland, its middle portion, or the isthmus connecting the two lateral lobes; the trachea, covered by a plexus of veins formed by the anastomoses of the inferior thyroid veins; the middle thyroid artery, when present, and the pretracheal fascia.

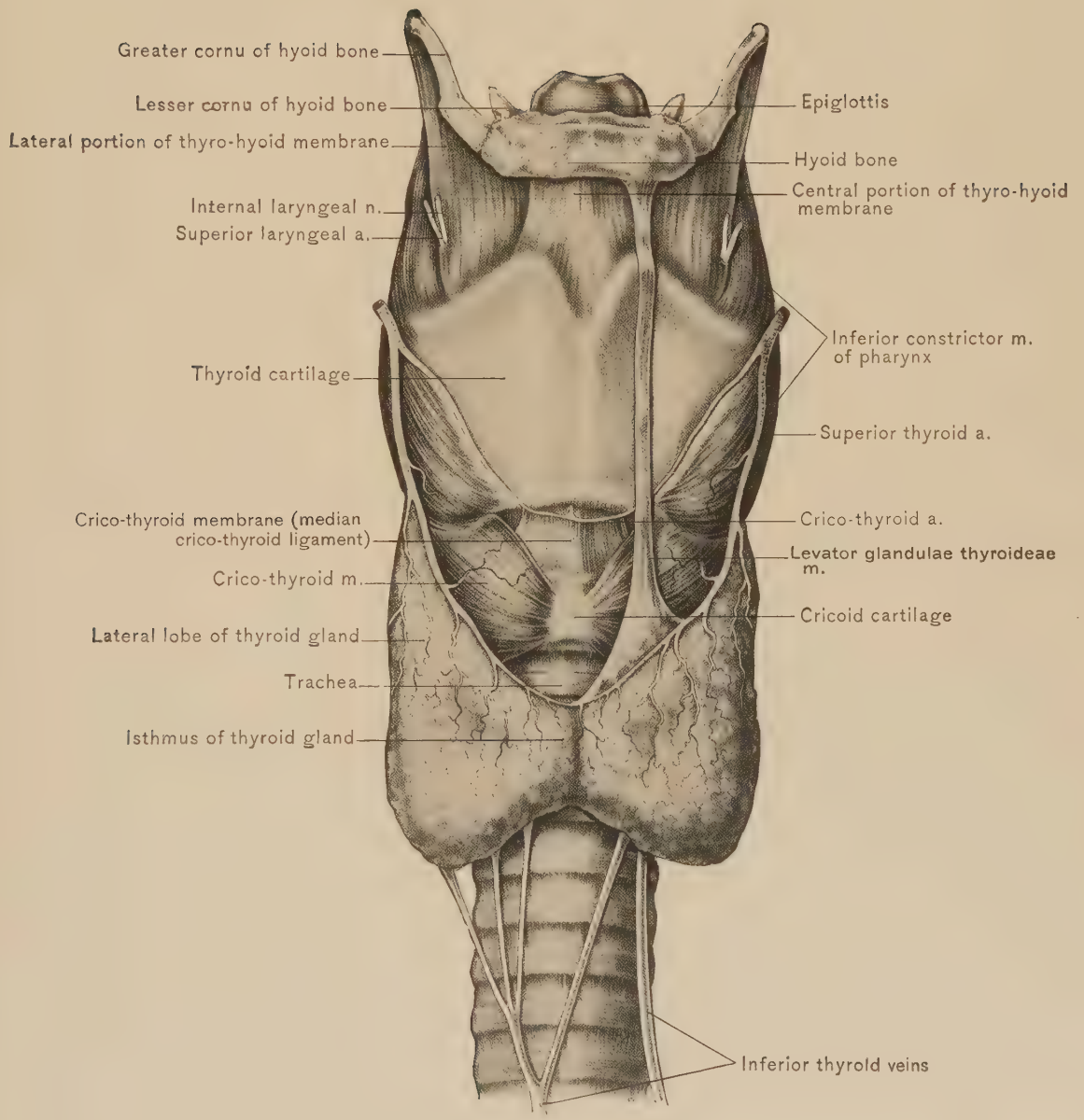
The **Thyroid Gland, or Body** (Plates CCLVII; CCLVIII), is a ductless and very vascular structure, situated in the neck on the front and sides of the upper part of the trachea, and the sides of the lower part of the larynx. It consists of two lateral lobes, the right one being the larger, connected by the isthmus, or middle lobe, and weighs about 30 grms.; each lateral lobe is about five centimeters (two inches) in length, three centimeters (one and one-fourth inches) in breadth, and two centimeters (three-fourths of an inch) in thickness. Each lateral lobe

PLATE CCLVII.



DEEP STRUCTURES OF NECK,—CAROTID ARTERIES AND VAGUS NERVE.

PLATE CCLVIII.



THYROID GLAND.

is pyriform or cone-shaped, with the apex directed upward; it extends from the fifth or sixth ring of the trachea to the middle of the side of the thyroid cartilage. Although symmetrical in general it is not so in detail. Anteriorly, it is convex, and is situated between the trachea and the sheath of the common carotid artery. It is covered anteriorly by the sterno-hyoid, the sterno-thyroid, and the anterior belly of the omo-hyoid muscle, being separated from these muscles by the middle layer of the cervical fascia. Its deep surface is concave and in contact with the trachea, larynx, pharynx, esophagus, the inferior thyroid artery, and the recurrent laryngeal nerve. From the upper part of the isthmus, or more commonly from the left lobe, a conical piece, called the *pyramidal* process, sometimes ascends toward the hyoid bone, to which it is attached by a fibrous band in front of the thyro-hyoid membrane, or by a slip of muscle, the *levator glandulæ thyroideæ of Soemmering*. The process is usually considered to be a remnant of the median anlage of the thyroid. The middle lobe, or isthmus, varies much in its dimensions, and is sometimes absent; or it may be entirely separated from both lateral lobes, thus forming an independent middle lobe. It is from one to two and a half centimeters (three fourths to one inch) in breadth, and rests upon the second and third rings of the trachea. A space is found between the upper border of the middle lobe, or isthmus, and the cricoid cartilage, where the trachea is not covered by the gland; this is the portion of the trachea that is opened in a high tracheotomy. To perform this operation when the space is covered by the middle lobe, it is necessary either to displace the lobe downward or to divide it between ligatures. A low tracheotomy is performed below the isthmus of the gland. This operation, although the preferable one, is the more difficult of the two, due, as is seen at a glance in the dissected neck, to the increasing depth of the trachea as it approaches the sternum, and the presence of the thyroid plexus of veins in front of this part of the trachea. An abnormally high position of the large vessels at the root of the neck would add to the difficulty and the danger of the low operation. However, in cases where the tracheotomy tube is to remain in situ for a considerable time the low operation is the one of choice since there is not the same danger of its causing laryngeal stenosis as in the high operation. The thyroid gland is closely attached by areolar tissue to the sides of the trachea and the cricoid and thyroid cartilages. During deglutition it rises and falls with the larynx, a fact of the utmost value in the differential diagnosis between cervical tumors and enlargement of the gland. It varies in size in different individuals and at different periods of life, being relatively larger in children and in females. This is especially true at the time of puberty when a physiological hypertrophy occurs. This type of enlargement is often injudiciously subjected to surgery. It often enlarges during menstruation. In old age the gland

decreases in size, becomes firmer, and at times contains calcareous substances. When enlarged, it may displace and compress the trachea, especially if the enlargement takes place rapidly, the body of the gland being held down by the sterno-thyroid and omo-hyoid muscles; or it may displace the great vessels of the neck laterally, so that the common carotid artery may be felt pulsating at the lateral border of the sterno-mastoid muscle. Venous engorgement may also ensue, and the recurrent laryngeal nerve may suffer from the pressure of an enlarged thyroid gland. Because of the fact that the isthmus, or middle lobe, binds together the enlarging lateral lobes of a large goiter, division of the isthmus has been performed to relieve dyspnea in such cases. The lateral borders of the thyroid gland being in contact with the sheath of the common carotid artery, the gland, when enlarged, may readily receive transmitted pulsations from that vessel. The error is occasionally made of mistaking a pulsating goiter for aneurysm of the common carotid artery. The common carotid is usually behind the thyroid, while the internal jugular is usually beyond it.

The median lobe of the thyroid gland is developed as a down-growth of the epithelium from the posterior part of the tongue; the starting point being the site indicated in the adult by the foramen cecum of the tongue. The canal thus formed is known as the *thyro-glossal duct*, or *canal of His*. Its walls normally disappear, but remnants are frequently found in the pyramidal process of the thyroid gland. Accessory thyroid glands, occurring near the median line of the neck in the vicinity of the hyoid bone and elsewhere in the neck, are regarded as being formed by division of the pyramidal process. Furthermore, certain cystic tumors at the base of the tongue and in the median line of the neck, as well as the cases of median cervical fistula, result from incomplete obliteration of the thyro-glossal duct.

The deep surface of the thyroid gland being in relation with the lower part of the pharynx and the upper part of the esophagus, explains the difficulty in swallowing often produced by large goiters, due to direct pressure and interference with the movements of the larynx. Enlargement of the left lobe of the gland is more likely to occasion difficulty in swallowing than enlargement of the right lobe, owing to the inclination of the esophagus toward the left. In a case mentioned by Allan Burns, the isthmus was located between the trachea and the esophagus. It is very evident that enlargement of this portion of the gland holding such an abnormal relation would occasion great difficulty in swallowing. The author has seen a case of goiter in which the esophagus was so nearly occluded that the patient was unable to swallow liquids. Insufficiency (hypothyroidism), atrophy, absence or destruction of the thyroid secretion gives rise to such conditions as myxedema and cretinism; while excess of thyroid secretion (hyperthy-

roidism, or thyrotoxicosis) causes a symptom-complex characterized chiefly by cardio-vascular derangement, enlargement of the thyroid gland, bulging of the eyeballs (exophthalmos), muscular tremor and weakness, and various gastro-intestinal symptoms. The condition is variously known as Grave's disease, Basedow's disease, exophthalmic goiter, or toxic goiter. Adenomata of the thyroid gland, the result of fetal inclusions, may, at sometime in the life of the individual, give rise to toxic symptoms simulating Grave's disease. The successful operative treatment of the disorder occupies a prominent place in modern surgery.

The **arteries of the thyroid gland** are the superior, inferior, and occasionally, the middle thyroid, or thyroidea ima, arteries. The *superior thyroid*, the first branch of the external carotid, ramifies chiefly upon the anterior aspect of the gland, entering it through the superior pole on its anterolateral aspect; the two arteries send branches to the interior of the gland, and sometimes meet on the isthmus. The *inferior thyroid*, a branch of the thyro-cervical trunk given off by the subclavian artery, enters the inferior medial surface of the lateral lobe of the gland. A very free anastomosis is established between these vessels, which form a complete network around the acini in the substance of the gland. Occasionally, there is a middle thyroid artery, the *thyroidea ima*, a branch of the innominate artery or of the arch of the aorta, which ascends in front of the trachea and enters the isthmus of the gland.

The thyroid gland is surrounded by a thin, dense, fibrous capsule, which is derived from the pretracheal fascia and sends processes into the interior which separate the substance into lobules of varying form and size. The vesicles composing these lobules are lined by a single layer of columnar epithelium, and contain a colloid substance. Increase of this colloid substance constitutes a colloid goiter.

The **nerves of the thyroid gland** accompany the superior and inferior thyroid arteries. They are derived from the middle and lower cervical sympathetic ganglia, from the superior laryngeal branch of the vagus, and possibly some small branches from the hypoglossal nerve. The recurrent laryngeal nerve comes in close contact with the thyroid gland by passing either anterior or posterior to the inferior thyroid artery at the inferior pole. This close relation is of practical importance in enlargement of the thyroid gland and concomitant enlargement of the arteries.

The **thyroid veins** are very numerous, forming a plexus beneath the capsule of the gland whence arise the superior, middle, and inferior thyroid veins. The *superior* and *middle thyroid veins* cross in front of the common carotid artery, emptying into the internal jugular vein, the superior occasionally emptying into

the facial (*anterior facial*) vein. The *inferior thyroid veins* descend on the trachea, form a plexus in front of the pretracheal fascia, and behind the sterno-thyroid muscles, and empty into the left innominate vein.

The **lymphatics of the thyroid gland** are numerous and large, and begin in the thyroid as perifollicular lymph spaces. Some pass into the lymph trunks at the root of the neck and thence into the pretracheal nodes, while others pass upward to the nodes in front of the larynx, and still others pass to the deep glands around the carotid vessels. In some cases these lymphatics have been found to contain colloid substance, giving rise to the supposition that they act as ducts of the gland.

Thyroidectomy.—In exposure of the thyroid gland a transverse curved incision concave upward, is made, and may be carried over the most prominent portion of the tumor. However, it is preferable to make the incision low down in the neck so that the scar will not be too prominent. The sterno-hyoid and sterno-thyroid muscles must frequently be severed in order to get adequate exposure. The gland being exposed, the superior and inferior thyroid arteries should be carefully freed, and then secured and divided between ligatures. In exposing the inferior thyroid artery preparatory to severing it, and in freeing the lower end of the posterolateral lobe of the gland, care must be exercised to avoid injuring the recurrent laryngeal nerve. Where much periglandular inflammation has occurred, the recurrent laryngeal nerve may be involved in the deposit of exudate, giving rise to aphonia, which is likely to be permanent whether or not the goiter is removed. It is well to remember that in operating for an adenoma of the thyroid the tumor can usually be enucleated after the capsule of the thyroid has been opened. In toxic goiters the rule is to stay anterior to the posterior capsule. In this way the recurrent laryngeal nerve and the parathyroid bodies are not likely to be damaged. Complete thyroidectomy is not compatible with the patient's future well-being, since it leads to myxedema; therefore, the subtotal operation is the one of choice. Care must be taken in separating the gland from the trachea, since traumatism of the latter would add to the patient's postoperative discomfort.

The **recurrent laryngeal** (**recurrent**) **nerve,** which has been described with the vagus nerve, should now be observed passing upward in the groove between the trachea and esophagus and behind and medial to the lateral lobe of the thyroid gland to enter the larynx.

The **parathyroid bodies** are small elliptical glands situated posterior and lateral to the thyroid. They are derived from the third and fourth pharyngeal pouches. There are usually two on each side. The *superior* pair are found opposite the level of the cricoid cartilage; the *inferior* pair are below and more

anterior and are not so constant in their location. The blood supply is from the inferior thyroid arteries.

The Subclavian Artery (Plate CCLII).—The origin, course, and relations of the subclavian arteries differ upon the two sides, the right subclavian being a branch of the innominate artery, and the left of the arch of the aorta. The scalenus anterior muscle passes in front of the subclavian artery and divides it into three portions. The *first portion* is situated between its origin and the medial border of the scalenus anterior muscle, the *second portion* behind the muscle, and the *third portion* between the lateral border of the muscle and the lower border of the first rib. The first portion of the artery is the one which differs in its course and relations on the two sides; it will, therefore, be described separately.

The **right subclavian artery** arises as one of the two terminal divisions of the innominate artery behind the upper border of the right sterno-clavicular articulation. The *first portion* of the artery lies deep in the neck, and ascends upward and lateralward to the medial border of the scalenus anterior muscle. It is covered anteriorly by the skin, the superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the sternal end of the clavicle, the sterno-mastoid muscle, the anterior jugular vein, the sterno-hyoid and sterno-thyroid muscles, and the posterior process of the prevertebral fascia, continued forward from in front of the scaleni muscles. It is crossed by the internal jugular and vertebral veins, the vagus nerve, the superior cardiac nerves, a loop, the ansa Vieussenii (*ansa subclavia*) of the cervical sympathetic, and the phrenic nerve. Below the artery are the pleura, the recurrent laryngeal nerve, and the subclavian vein; behind it are the recurrent laryngeal nerve, the cord of the cervical sympathetic nerve with its middle and inferior cardiac branches, the longus colli muscle, the transverse process of the seventh cervical or first thoracic vertebra, from which it is separated by a small quantity of cellular tissue and fat, and the apex of the lung, covered with pleura.

The **left subclavian artery,** the longer of the two, arises from the transverse portion of the arch of the aorta opposite the third thoracic vertebra. Its first portion ascends almost vertically to the medial margin of the first rib and the medial border of the insertion of the scalenus anterior muscle. (Only the relations of the cervical part of this portion of the artery will be described here.) The *cervical part of the first portion* is covered by: the skin, the superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the sterno-mastoid muscle, the anterior jugular vein, the sterno-hyoid and sterno-thyroid muscles, the posterior process of the deep fascia, continued forward from in front of the scaleni muscles, the sternal end of the clavicle, the left internal jugular vein, the vertebral and subclavian veins, the apex of the left lung and its pleura, the phrenic

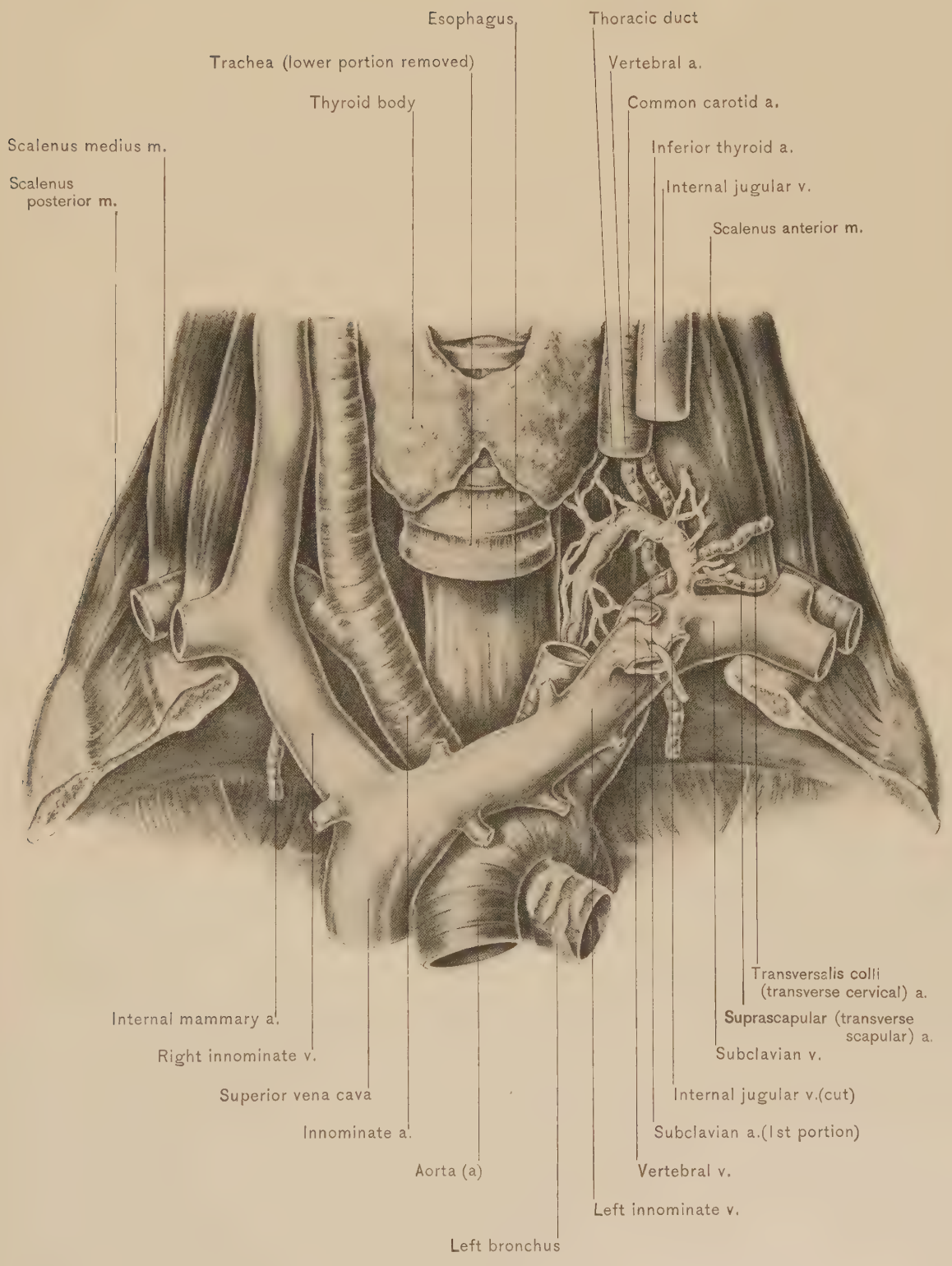
nerve, and the cardiac branches of the cervical sympathetic, which lie parallel with the artery, the left common carotid artery, and the thoracic duct. On its lateral side are the apex of the lung and pleura; on its medial side are the trachea, the recurrent laryngeal nerve, the esophagus, and the thoracic duct; behind it are the pleura and the apex of the left lung, while behind and medial to it are the thoracic duct, the esophagus, the inferior cervical ganglion of the cervical sympathetic, the sympathetic trunk, the longus colli muscle, and the spinal column.

The *Differences between the Right and Left Subclavian Arteries in their First Portion* are as follows: the *left subclavian* arises directly from the arch of the aorta, while the *right* arises from the innominate artery; the left lies deeper, is longer and more vertical; it is in relation with the esophagus and the thoracic duct, while the right is not; it is crossed by the left innominate, or brachio-cephalic, vein, the phrenic and vagus nerves, and the cardiac branches of the cervical sympathetic, running almost parallel with it; on the right side the phrenic and vagus nerves and some of the cardiac branches of the cervical sympathetic pass in front of the right subclavian artery, nearly at a right angle. The relation of the left subclavian artery with the recurrent laryngeal nerve is not so close as the right, the nerve winding around below the latter. The thoracic duct is in relation with the first portion of the left subclavian artery at two points, although it holds no relation to the right subclavian artery.

The **thoracic duct** (Plate CCLIX) passes upward to the left of the esophagus and behind the aorta and the first portion of the left subclavian artery and the apex of the left lung through the upper aperture of the thorax. Behind the left internal jugular vein and common carotid artery and opposite the seventh cervical vertebra, the duct forms an arch above the subclavian artery and anterior to the vertebral artery and vein, and descends in front of the scalenus anterior muscle to empty into the left subclavian vein at its junction with the internal jugular vein.

The Second Portion of the Subclavian Artery.—The relations of the second and third portions of the subclavian artery are alike on both sides. In its second portion the artery lies behind the scalenus anterior and in front of the scalenus medius muscle; at this point it rises highest above the clavicle, usually about two centimeters (three-fourths of an inch). It is covered by the skin, the superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the clavicular origin of the sterno-mastoid muscle, the posterior process of the deep fascia, the phrenic nerve, and the scalenus anterior muscle, the latter separating it from the subclavian vein. Above it lies the lowest of the three cervical trunks of the brachial plexus of nerves. Behind it are the scalenus medius muscle and the

PLATE CCLIX.



THORACIC DUCT.

apex of the lung and of the pleura. Below it lies the pleura, while below and in front of it is the sublcavian vein. This portion gives off only one branch, the superior intercostal artery (*costo-cervical trunk*).

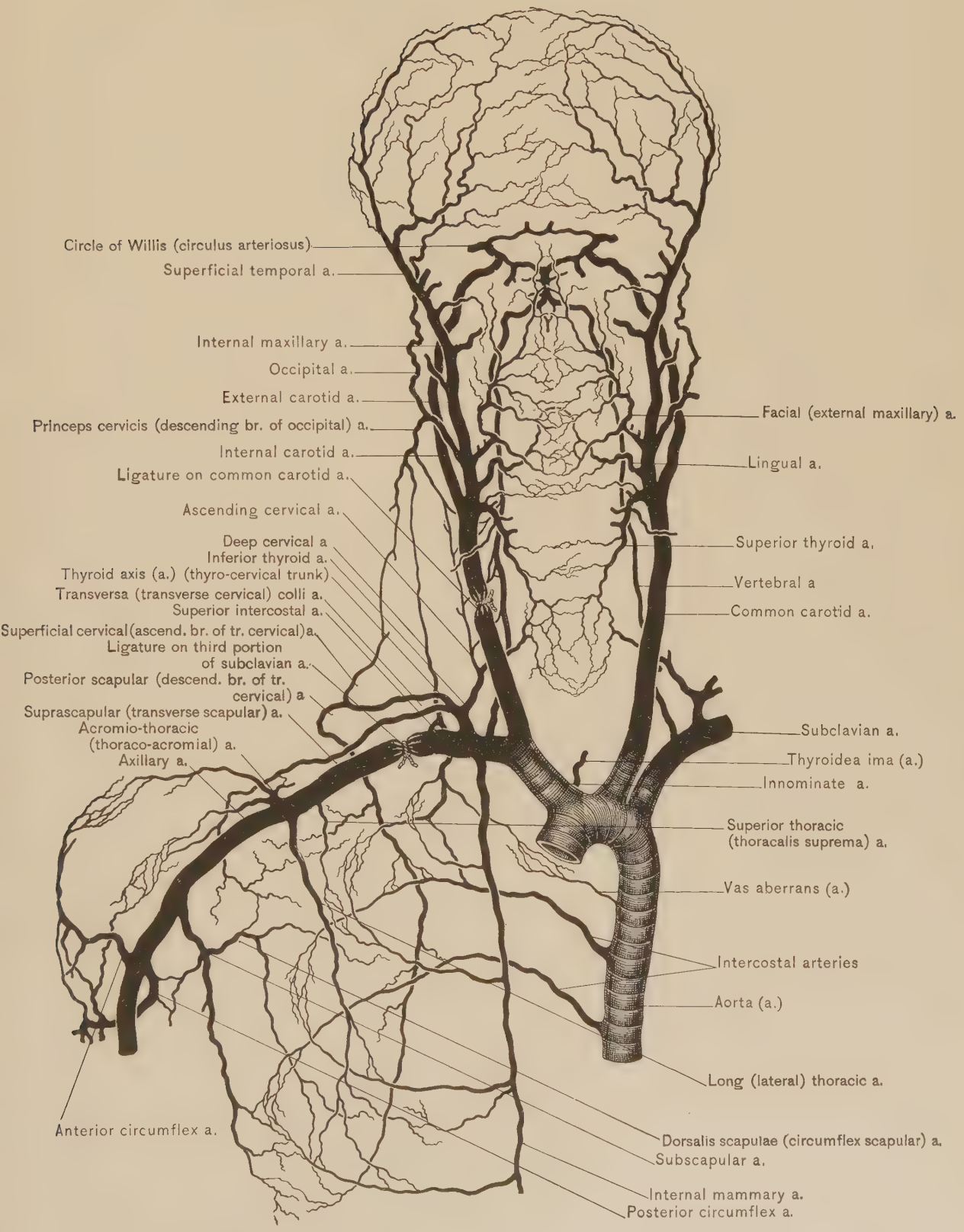
The Third Portion of the Subclavian Artery passes downward and lateralward from the lateral margin of the scalenus anterior muscle to the lower border of the first rib, occupying the subclavian triangle, where it is nearer the surface than in either the first or second portion of its course. It is covered by the skin, the superficial fascia, the platysma muscle, the superficial layer and the posterior of the two processes of the deep fascia, and near its termination by the clavicle and subclavius muscle. Running in front of this portion are the suprascapular (*transverse scapular*) artery and vein, while crossing it are the clavicular branches of the cervical plexus, the nerve to the subclavius muscle, and the external jugular vein. The transverse cervical, suprascapular (*transverse scapular*), posterior (*posterior external*) jugular, and anterior jugular veins frequently form a plexus in front of the artery, and should be borne in mind in ligating the third portion of the subclavian artery; they empty into the external jugular vein. The relation between the suprascapular (*transverse scapular*) artery and the third portion of the subclavian artery at its point of election may be compared, surgically, to the relation between the middle sterno-mastoid and the common carotid artery at its point of election; the anatomic difference being that the middle sterno-mastoid artery passes across the sheath of the common carotid, and is frequently severed in ligation of the latter, while the suprascapular (*transverse scapular*) passes in front of, and almost parallel with the subclavian artery, and can be displaced when the main vessel is ligated. The subclavian vein lies below the artery, and on a plane anterior to it. Above and to the lateral side of this portion of the artery are the three cervical trunks of the brachial plexus of nerves and the omo-hyoid muscle. The upper trunk runs so close to, and so nearly parallel with the artery that it may be mistaken for it and tied, the surgeon being misled by the pulsation communicated to the nerve. Behind the artery are the scalenus medius muscle and the lowest cervical trunk of the brachial plexus. Below this portion of the artery is the first rib. The third portion of the subclavian artery, as a rule, does not give off branches, but occasionally gives origin to the posterior scapular (*descending branch of the transverse cervical*) artery.

Variations of the subclavian artery. The right subclavian artery may arise as a separate trunk from the arch of the aorta. It may pass in front of or through the fibers of the scalenus anterior muscle, and ascend as high as four centimeters (one and a half inches) above the clavicle. In some cases the subclavian vein passes with the artery behind the scalenus anterior muscle.

Ligation of the third portion of the subclavian artery. The third portion is the point of election for ligation of the subclavian artery. In this portion it is most superficial, is covered by fewer important structures, and, as a rule, does not give off any branches; the posterior scapular (*descending branch of the transverse cervical*) artery occasionally arises from it. When performing this ligation the patient should be placed in the supine position, with a pillow beneath the upper part of the back, and the shoulder depressed. The incision, eight to ten centimeters (three to four inches) in length, is made parallel with the upper border of the clavicle, commencing at the lateral border of the clavicular origin of the sterno-mastoid muscle. The vessel is brought nearer the surface by carrying the arm to the side and depressing the shoulder, thus diminishing the depth of the triangle through which the artery passes. The relation of the suprascapular (*transverse scapular*) vessels to the third portion of the subclavian artery is so changed when the arm is well drawn down that it is not endangered in the ligation. The following structures are divided: the skin, the superficial fascia, the platysma muscle, some of the clavicular branches of the cervical plexus, the superficial layer of the deep fascia, and the posterior of its two processes (prevertebral fascia). The external jugular vein, with the veins emptying into it, which frequently form a plexus above and in front of the subclavian artery between the two layers of the deep fascia (superficial and prevertebral), should be pushed aside; if this is not feasible, they may be tied and severed between ligatures. The posterior belly of the omo-hyoid muscle should next be exposed by dividing the connective tissue at the bottom of the wound; the operator should then search for the uppermost cervical trunk of the brachial plexus and the lateral border of the scalenus anterior muscle, along which the finger is passed until the tubercle on the first rib is reached, provided the vessel is not felt pulsating before the finger reaches the rib. When the pulsation of the artery is felt, its sheath should be opened and the aneurysm needle, carrying the ligature, passed from before backward, away from the vein, and then from below upward, care being taken to avoid including the lowest of the three cervical trunks of the brachial plexus, which runs behind and nearly parallel with the third portion of the subclavian artery. In very muscular subjects, in addition to the above structures, it may be necessary to divide a portion of the clavicular head of the sterno-mastoid and the anterior border of the trapezius muscle.

After this ligation the *collateral circulation* (Plate CCLX) is carried on by the anastomosis of the suprascapular (*transverse scapular*) and posterior scapular (*descending branch of the transverse cervical*) arteries with the dorsalis scapulæ and the terminal portion of the subscapular artery, the suprascapular (*transverse scapular*) above, with the acromio-thoracic (*thoraco-acromial*) and posterior

PLATE CCLX.



COLLATERAL CIRCULATION AFTER LIGATION OF SUBCLAVIAN AND COMMON CAROTID ARTERIES.

circumflex arteries below, and by the anastomosis of the superior thoracic (*thoracalis suprema*), thoracic branches of the acromio-thoracic (*thoraco-acromial*), the long thoracic (*lateral thoracic*), and the subscapular artery, with the aortic intercostal arteries, the internal mammary, and the superior intercostal arteries (*costo-cervical trunk*).

Ligation of the second portion of the subclavian artery is very rarely performed. The vessel is exposed by an incision along the clavicle; the clavicular head of the sterno-mastoid muscle is divided, the connective tissue cleared away, and any veins which may be found overlying the prevertebral fascia covering the scalenus anterior muscle are tied. The prevertebral fascia is divided, the phrenic nerve carried medialward, and the scalenus anterior muscle severed near its attachment to the first rib, care being taken not to injure the anterior jugular, external jugular, internal jugular, and subclavian veins, and the pleura. The needle should be carried from before backward and from below upward to avoid injuring the vein.

Ligation of the first portion of the subclavian artery, especially of the left, is the most difficult and the most dangerous of the three ligations. This portion of the vessel lies deeper than the other two, is surrounded more intimately by important structures, and gives off three branches. (See description of the relations of the first portion at p. 555). To expose the first portion of the vessel on the right side make a triangular flap, like that made in tying the innominate artery, by carrying one incision along the medial border of the sterno-mastoid muscle and another one along the superior border of the clavicle. The skin, superficial fascia, platysma muscle, superficial layer of the deep fascia, and the anterior jugular vein are divided. The sternal head of the sterno-mastoid muscle, and, if necessary, the clavicular head, as well as the sterno-hyoid and sterno-thyroid muscles at their origin, are divided. The inferior thyroid veins, now seen at the bottom of the wound, should be held aside or divided between ligatures, and the root of the common carotid artery exposed; this artery is then followed downward to the innominate, thus reaching the first part of the subclavian artery. To expose the first portion of the left subclavian artery a flap similar to that on the right should be made. The sterno-mastoid, the sterno-hyoid, and the sterno-thyroid muscles are divided, and the apex of the left lung, with the structures running parallel to and in front of the artery (see description of the relations of the first portion of the left subclavian artery at p. 555), should be drawn forward, avoiding the vertebral and internal jugular veins. The needle is passed from below upward; in carrying the needle behind the artery, great care must be exercised to avoid wounding the thoracic duct and the pleura. The first portion is rarely ligated. The procedure is difficult, even more so on the left than on the

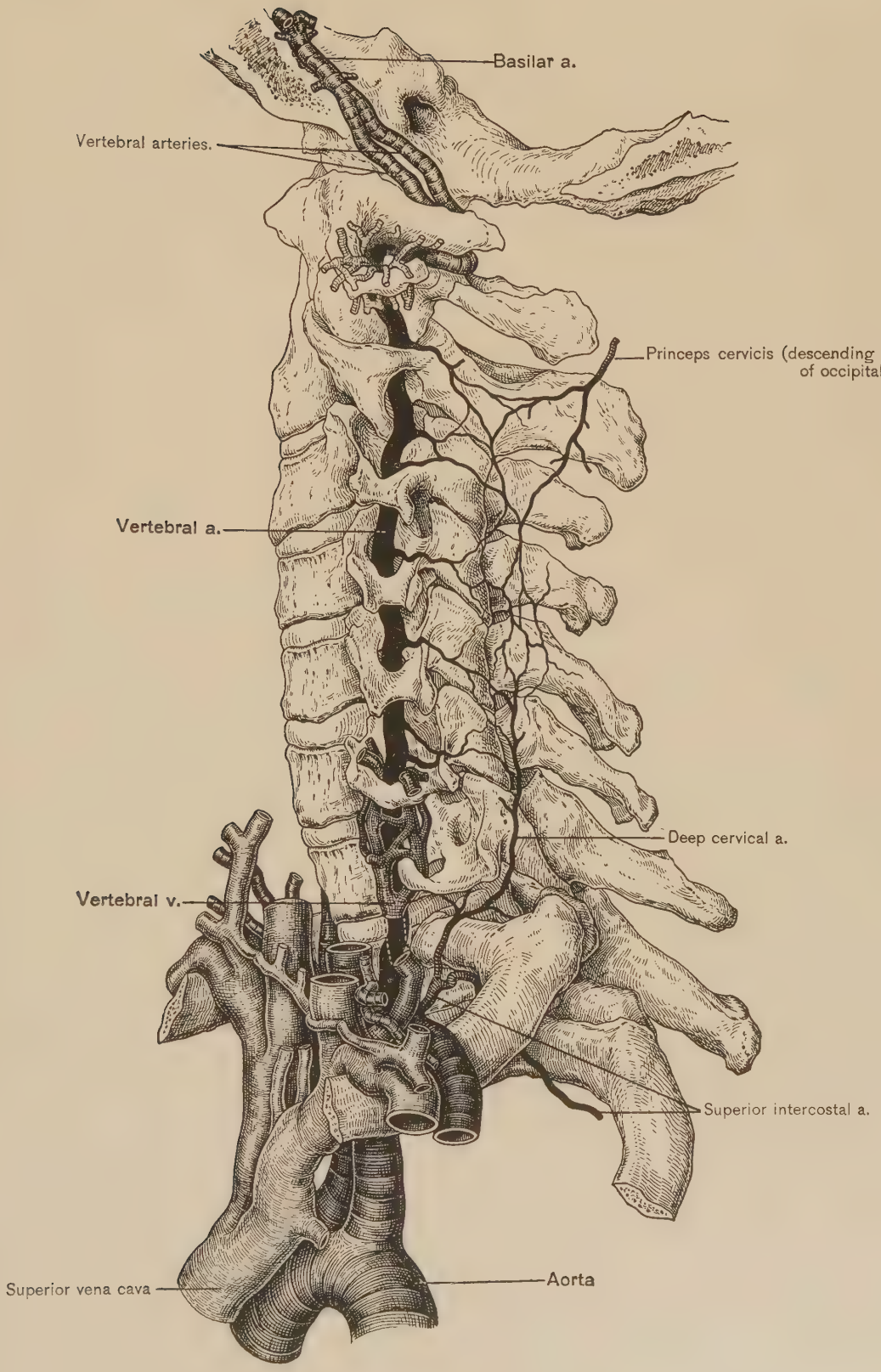
right, because of the depth, the numerous branches, and the contiguity of the surrounding important structures.

Branches of the Subclavian Artery.—These consist of the vertebral, the thyroid axis (*thyro-cervical trunk*), the internal mammary, and the superior intercostal artery (*costo-cervical trunk*), the last-named branch arising from the first portion on the left side and the second portion on the right. The other branches all arise from the first portion, except the transverse cervical which may arise independently from the third portion. In the majority of cases the third portion gives off no branches, but the posterior scapular (*descending branch of transverse cervical*) artery frequently arises from it.

The **Vertebral Artery** (Plate CCLXI), the first and largest branch, arises from the upper and back part of the first portion of the subclavian artery and supplies chiefly the spinal cord and the brain. It ascends in the interval between the scalenus anterior and longus colli muscles, entering the foramen in the transverse process of the sixth cervical vertebra, just below the level of the lower border of the cricoid cartilage, and continues upward through the foramina in the transverse processes of the remaining cervical vertebræ to the skull. After passing through the foramen in the transverse process of the axis (*epistropheus*), it takes an S-shaped course upward and lateralward, which prevents its being stretched when the head is rotated. It then passes through the foramen in the transverse process of the atlas, curving backward behind the articular process in a deep groove on the superior surface of the posterior arch of the atlas. Here it lies in the suboccipital triangle, and pierces the posterior occipito-atloid ligament (*posterior atlo-occipital membrane*) and the dura mater of the spinal cord; it enters the foramen magnum and becomes intracranial. It unites with the vetebral artery of the opposite side near the lower border of the pons to form the basilar artery, which, after dividing into the posterior cerebral arteries, assists in forming the circle of Willis (*circulus arteriosus*).

Owing to its peculiar course the artery may be divided into four parts. The first, or *cervical portion, of the vertebral artery* lies behind the internal jugular vein, the inferior thyroid artery, and the vertebral vein, while near the transverse process of the sixth cervical vertebra it lies between the scalenus anterior and longus colli muscles; the thoracic duct lies in front of the left vertebral artery. The second, or *vertebral, portion* lies within the canal formed by the foramina of the transverse processes of the upper six cervical vertebræ, and is accompanied by the vertebral veins and the vertebral plexus of nerves derived from the inferior cervical sympathetic ganglion; it lies between the vertebral vein anteriorly, and the cervical nerves which pass out of the spinal canal through the intervertebral foramina, posteriorly. It is in contact with the intertransverse muscles. Its

PLATE CCLXI.



VERTEBRAL ARTERY IN TRANSVERSE PROCESSES.

third, or *occipital, portion* lies in the groove on the posterior arch of the atlas, where it rests upon the suboccipital nerve, and is within the suboccipital triangle formed by the rectus capitis posterior major muscle upon the medial side, the obliquus capitis superior above, and the obliquus capitis inferior muscle below; it is covered by the complexus (*semispinalis capitis*) muscle. The relation which the fourth, or *intracranial, portion* holds within the cranial cavity is described under the Dissection of the Brain (see Vol. I).

The Branches of the Vertebral Artery consist of two sets: cervical branches given off in the neck and cranial branches given off within the cranium. The branches given off in the neck are the lateral spinal and the muscular.

The *lateral spinal* (*spinal*) *arteries* pass through the intervertebral foramina, and each divides into two branches for the supply of the spinal cord, its membranes, and the bodies of the vertebræ.

The *muscular branches* are given off immediately before the vertebral artery pierces the occipito-atloid ligament (*posterior atlo-occipital membrane*); they supply the deep muscles of the neck, and anastomose with the occipital and the ascending and deep cervical arteries.

Digital compression of the vetebral artery is possible below the sixth cervical vertebra at Chassaignac's tubercle, pressure being exerted in the line of the great vessels. This is the same site as for pressure on the common carotid artery.

The *vertebral vein* is formed in the suboccipital triangle from a plexus of veins composed of numerous small branches from the deep muscles. It enters the foramen in the transverse process of the atlas, and forms a plexus around the vertebral artery. At the lower part of the neck the plexus unites to form the vertebral vein, which emerges at the foramen in the transverse process of the sixth cervical vertebra, whence it passes downward in front of the vertebral artery and behind the internal jugular vein and terminates in the innominate vein near its origin, passing in front of the first portion of the subclavian artery. Its orifice is guarded by a pair of valves. It receives as tributaries the veins from the neighboring muscles; the dorsi spinalis, or extraspinal, veins (*posterior external plexuses*), the meningo-rachidian, or intraspinal, veins from the spinal canal (*internal vertebral plexuses*), the deep cervical, and, at times, the first pair of intercostal veins. When the posterior condyloid foramen (*condyloid canal*) is present, the vertebral vein communicates with the lateral sinus by a branch which passes through the foramen.

Ligation of the vertebral artery is performed through an incision carried along the lower part of the posterior border of the sterno-mastoid muscle, which corresponds to the lateral border of the scalenus anterior muscle. The skin, superficial fascia, platysma muscle, and the superficial layer of the deep fascia

are divided, the external jugular vein being displaced lateralward. The sternomastoid muscle is drawn toward the median line, and the connective tissue divided or pushed aside with the handle of the scalpel, thus exposing the prevertebral fascia, or posterior process of the deep cervical fascia, which covers the scalenus anterior muscle and the phrenic nerve. The posterior process of the deep cervical fascia, the prevertebral fascia, is divided on a line with the medial border of the scalenus anterior muscle; the vertebral artery with its companion vein, which partly covers it, will be found occupying the interval between the scalenus anterior and the longus colli muscles. The inferior thyroid artery, which lies in front of the vertebral artery, must not be mistaken for it. The dissection to expose the vessel must be carefully done in order to avoid wounding the phrenic nerve and the internal jugular vein, or opening the pleural sac. The inexperienced operator may be led to believe he has opened the pleural sac, by the crackling sound occasioned by air infiltrating the connective tissue occupying this position. The vertebral vein must be slightly displaced before passing the aneurysm needle, which should be carried from without medialward to avoid injuring the vertebral vein, the internal jugular vein being protected with the tip of the finger. On the left side the thoracic duct should be avoided. Contraction of the pupil of the eye of the corresponding side, caused by the disturbance of the sympathetic filaments in relation with the artery, shows that the ligature has included the vertebral artery. The author has found this a reliable sign. The carotid tubercle, which is at the upper extremity of the groove between the scalenus anterior and longus colli muscles, is the deep guide to the artery.

The **Thyroid Axis** (**thyro-cervical trunk**), a short thick trunk, arises from the upper border of the subclavian artery near the medial border of the scalenus anterior muscle. It lies beneath the internal jugular vein and prevertebral fascia and between the phrenic nerve and the vertebral vein, ascending for two to ten millimeters and then dividing into three Branches: the inferior thyroid, suprascapular (*transverse scapular*), and transverse cervical arteries.

The **inferior thyroid artery,** the largest branch of the thyroid axis (*thyro-cervical trunk*), passes obliquely upward and medialward behind the internal jugular vein and in front of the vertebral artery, and medialward behind the sheath of the common carotid artery and the cervical sympathetic to the deep surface of the lateral lobe of the thyroid gland, which it supplies and within which it anastomoses with the superior thyroid artery and the inferior thyroid artery of the opposite side. It turns medialward just below the carotid tubercle (anterior tubercle of the sixth cervical transverse process), and crosses behind the sheath of the vessels at about the level of the tendon of the omo-hyoid muscle. The recurrent laryngeal nerve crosses anterior or posterior to the artery as it turns

down to enter the thyroid gland. The middle cervical, or thyroid, ganglion of the cervical sympathetic rests upon the inferior thyroid artery. It gives off the following BRANCHES: ascending cervical, laryngeal, tracheal, esophageal, and muscular.

The *ascending cervical artery* arises from the inferior thyroid behind the internal jugular vein, and runs up the neck close to the tips of the transverse processes of the cervical vertebræ in the groove between the scalenus anterior and the rectus capitis anterior major (*longus capitis*) muscles, and to the medial side of the phrenic nerve. Its branches to the muscles of the neck communicate with the muscular branches of the vertebral artery, while others enter the intervertebral foramina to reach the bodies of the vertebræ and the spinal cord and its meninges. It anastomoses with the vertebral, ascending pharyngeal, and branches of the occipital artery. It sends a branch to the phrenic nerve.

The *inferior laryngeal artery* accompanies the recurrent laryngeal nerve, supplies the muscles and mucous membrane of the larynx, and anastomoses with the superior laryngeal artery.

The *tracheal branches* ramify upon the trachea, the lower ones anastomosing with the bronchial arteries.

The *esophageal branches* supply the esophagus. One of these is often large, and runs parallel with the continuation of the inferior thyroid artery, and may be mistaken for it.

The *muscular branches* supply the muscles of the lower anterior part of the neck.

The inferior thyroid artery is not accompanied by the corresponding vein, which lies at the side of the median line of the neck. (See Dissection of Front of Neck at p. 488.)

Ligation of the inferior thyroid artery.—This is performed either where the artery lies between the internal jugular vein and the medial border of the scalenus anterior muscle, or to the medial side of the carotid sheath as it passes to the deep surface of the lateral lobe of the thyroid gland just below the level of the cricoid cartilage. To secure the inferior thyroid artery along the medial border of the scalenus anterior muscle, make an incision similar to that made in ligating the vertebral artery, carrying the aneurysm needle from within lateralward away from the vertebral vein, while to secure the inferior thyroid artery on the medial side of the carotid sheath the incision is made along the anterior border of the sternomastoid muscle. When ligating the vessel close to the gland, it is well to remember that it is in intimate connection with the recurrent laryngeal nerve.

The **suprascapular (transverse scapular) artery** runs across the lower part of the neck, lying almost parallel with, but on a somewhat lower and more ante-

rior level than the superficial cervical (*ascending branch of transverse cervical*). At first, it passes beneath the sterno-mastoid muscle and over the phrenic nerve and the lower part of the scalenus anterior muscle; it then runs posterior to the clavicle and the subclavius muscle, crosses the third part of the subclavian artery, and passes beneath the posterior belly of the omo-hyoid and the anterior border of the trapezius muscle to the superior border of the scapula, where it passes over the transverse ligament of that bone to reach the supraspinous fossa. The suprascapular nerve, which joins the artery just before it dips under the omo-hyoid muscle, passes beneath the transverse ligament, and through the suprascapular (*small scapular*) notch. In the supraspinous fossa the artery lies close to the bone, and supplies the supraspinatus muscle; at the neck of the scapula it turns around the base of the spine to the infraspinous fossa, where it anastomoses with the dorsalis scapulæ (*circumflex scapular*), a branch of the subcapular artery, and with the posterior scapular (*descending branch of transverse cervical*) artery. The chief Branches of the suprascapular (*transverse scapular*) artery are the inferior sterno-mastoid, supra-acromial (*acromial*), and articular. Other branches supply the subclavius muscle, the skin over the manubrium sterni (suprasternal), and the clavicle.

The *inferior sterno-mastoid artery* supplies the clavicular portion of the sterno-mastoid muscle, behind which it is given off.

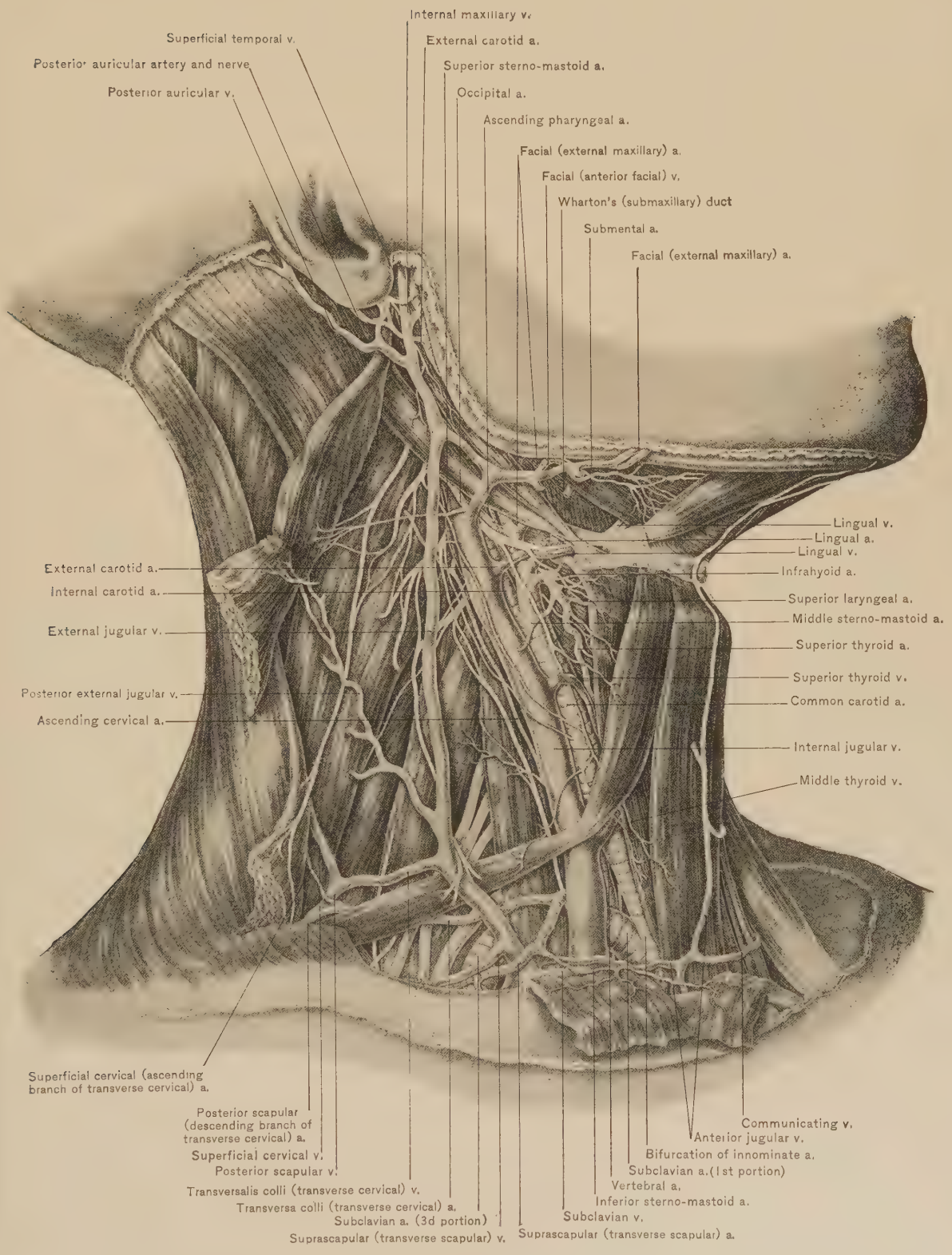
The *supra-acrominal* (*acromial*) *branch* pierces the trapezius muscle, passes over the acromion process, and anastomoses with the acromio-thoracic and posterior circumflex arteries.

The *articular branches* supply the acromio-clavicular joint and the shoulder-joint.

The **transverse cervical artery** (Plate CCLXII), which usually is larger than the suprascapular (*transverse scapular*) artery, passes lateralward across the side of the neck, higher than the suprascapular (*transverse scapular*), over the scaleni muscles and phrenic nerve, and over or between the cervical trunks of the brachial plexus to the anterior border of the trapezius, beneath which, and at the later border of the levator anguli scapulae (*levator scapulae*) muscle, it divides into its two terminal branches, the superficial cervical (*ascending branch*) and the posterior scapular (*descending branch.*)

The *superficial cervical* (*ascending branch of transverse cervical*) *artery*, the ascending branch, passes upward beneath the anterior border of the trapezius and over the levator anguli scapulae (*levator scapulae*) and splenius muscles. It supplies these muscles and the posterior chain of lymph glands in the neck, and anastomoses with the deep and ascending cervical arteries and the superficial branch of the arteria princeps cervicis (*descending branch of occipital*), which

PLATE CCLXII.



VESSELS OF NECK.

descends from the occipital artery between the splenius and complexus (*semi-spinalis capitis*) muscles.

The *posterior scapular* (*descending branch of transverse cervical*) *artery*, the descending branch, and the larger of the two terminal branches, passes beneath the trapezius and the levator anguli scapulæ (*levator scapulæ*) muscle to the superior angle of the scapula, whence it descends along the vertebral border, or base, of the scapula to the inferior angle. It runs between the insertions of the serratus magnus (*serratus anterior*) anteriorly and the rhomboidei and levator anguli scapulæ (*levator scapulæ*) posteriorly, and supplies those muscles as well as the latissimus dorsi and trapezius. It anastomoses with the suprascapular (*transverse scapular*) and subscapular arteries and with the posterior branches of the intercostal arteries. It frequently arises from the third portion of the subclavian artery as a descending branch of the transverse cervical which in these cases arises as a branch of the third portion and the superficial cervical artery arises from the thyroid axis (*thyro-cervical trunk*). In such cases the anastomosis between the ascending branch of the transverse cervical and the superficial cervical develops as the major channel for blood to reach the posterior scapular; the main trunk of the transverse cervical from the third portion then disappears and there is no branch from the third portion of the subclavian. When this obtains, the name transverse cervical is applied to the main stem of the superficial cervical, the latter name being given to the ascending branch of the original artery.

The **veins** corresponding to the branches of the thyroid axis (*thyro-cervical trunk*) empty into the external jugular vein, except the inferior thyroid vein, which goes to the innominate vein.

The **Internal Mammary Artery** arises from the lower margin of the first part of the subclavian artery opposite the thyroid axis (*thyro-cervical trunk*). It passes downward beneath the clavicle, the subclavius muscle, and the subclavian vein, and enters the chest between the cartilage of the first rib and the pleura. At its origin it is crossed from without medialward by the phrenic nerve. (Its further course is described under the Dissection of the Thorax, Vol. III.) The accompanying **veins** of the internal mammary artery, two in number, unite to form a common trunk which empties into the innominate vein.

The **Superior Intercostal Artery** (**Costo-cervical Trunk**) arises from the upper margin of the second portion of the subclavian artery, and occasionally from the first portion upon the left side. It arches backward and a little upward over the pleura, and then descends behind it, giving off the deep cervical artery; it then passes in front of the neck of the first, and sometimes of the second rib, giving off the arteries of the first, and sometimes of the second intercostal space, and a posterior branch, which is distributed to the muscles of the back and to the spinal

cord and its membranes. In front of the neck of the first rib it lies between the first thoracic sympathetic ganglion on the medial side, and the anterior branch of the first thoracic nerve on the lateral side. Occasionally the superior intercostal (*costo-cervical trunk*) arises from the vertebral artery. Its BRANCHES are the deep cervical, the first intercostal, and, at times, the second intercostal which may anastomose with the persisting arteria aberrans from the thoracic aorta.

The **deep cervical artery** passes backward between the seventh and eighth cervical nerves, and then between the transverse process of the last cervical vertebra and the neck of the first rib, medial to the scaleni medius and posterior muscles; thence it passes up the back of the neck between the complexus (*semispinalis capitis*) and semispinalis cervicis muscles, which it supplies, and anastomoses with the arteria princeps cervicis (*descending branch of occipital*) and branches of the ascending cervical and vertebral arteries.

The **deep cervical vein** begins in the suboccipital triangle, usually receives the occipital vein, accompanies the arteria princeps cervicis (*descending branch of occipital*), and then the deep cervical artery, and empties into the vertebral or into the innominate vein.

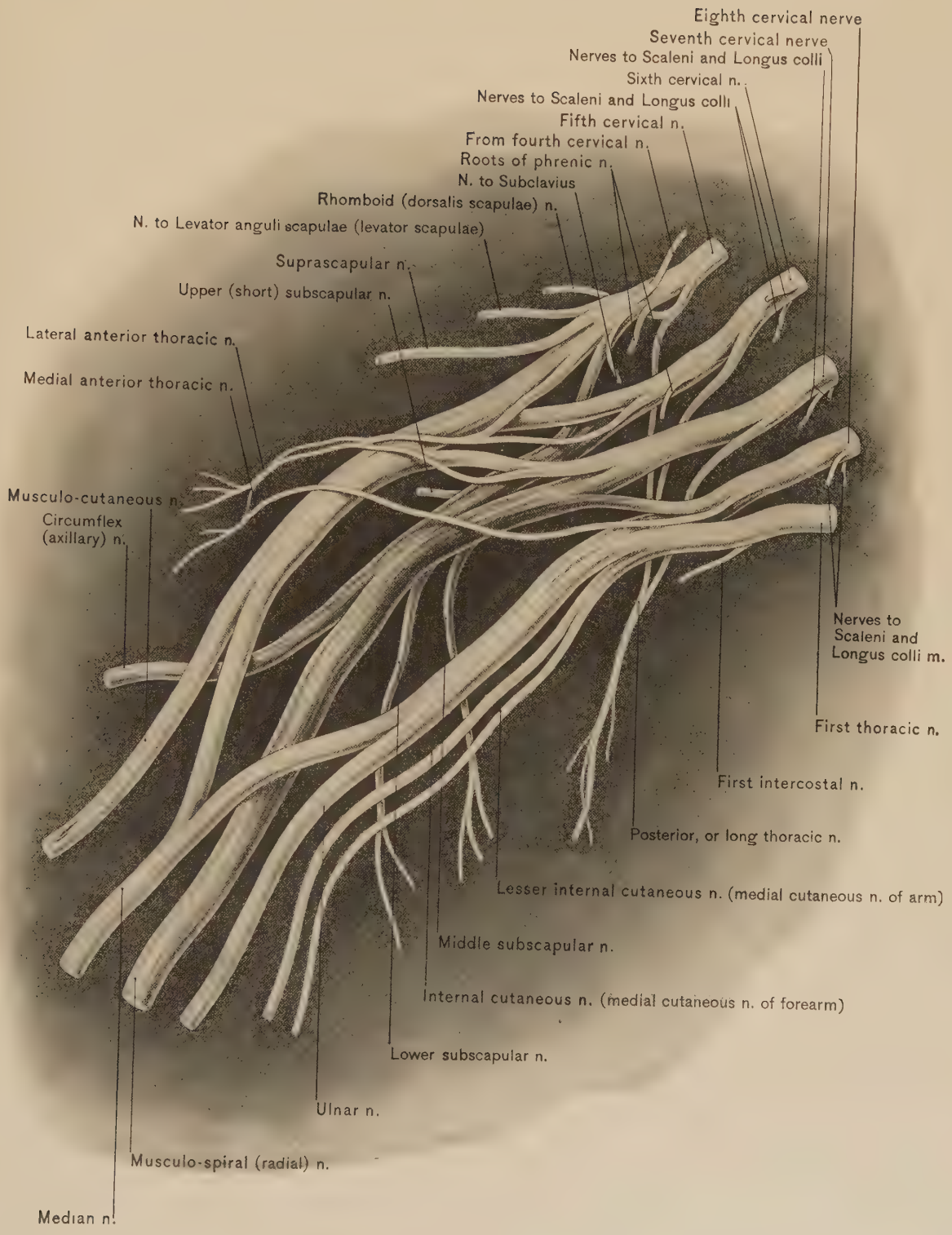
The **first intercostal artery** has a distribution in the first intercostal space corresponding with that of the arteries in the other intercostal spaces, while the *second* arises at the bifurcation of the superior intercostal (*costo-cervical trunk*) and supplies the second intercostal space.

The *anastomosis* between the superior intercostal (*costo-cervical trunk*) and the occipital arteries plays an important part in the development of the collateral circulation after ligation of the common carotid artery.

The **veins** which correspond to the superior intercostal arteries (*costo-cervical trunks*) are the right superior intercostal vein which empties into the vena azygos major or the right innominate vein; and the left superior intercostal vein which empties into the left innominate vein.

The Brachial Plexus (Plate CCLXIII).—The brachial plexus of nerves will be seen at the side of the neck emerging from between the scaleni anterior and medius muscles; it is formed by the union of the anterior primary divisions of the lower four cervical nerves and the first thoracic nerve. A small branch from the anterior division of the fourth cervical, and another from the second thoracic nerve usually enter the plexus. These branches form the cords of the plexus, from which are given off the branches that supply the upper extremity. The

PLATE CCLXIII.


Eighth cervical nerve
Seventh cervical nerve
Nerves to Scaleni and Longus colli
Sixth cervical n.
Nerves to Scaleni and Longus colli
Fifth cervical n.
From fourth cervical n.
Roots of phrenic n.
N. to Subclavius
Rhomboid (dorsalis scapulae) n.
N. to Levator anguli scapulae (levator scapulae)
Suprascapular n.
Upper (short) subscapular n.
Lateral anterior thoracic n.
Medial anterior thoracic n.
Musculo-cutaneous n.
Circumflex (axillary) n.
Nerves to Scaleni and Longus colli m.
First thoracic n.
First intercostal n.
Posterior, or long thoracic n.
Lesser internal cutaneous n. (medial cutaneous n. of arm)
Middle subscapular n.
Internal cutaneous n. (medial cutaneous n. of forearm)
Lower subscapular n.
Ulnar n.
Musculo-spiral (radial) n.
Median n.

BRACHIAL, OR AXILLARY, PLEXUS OF NERVES.

nerves in the neck—the *cervical,* or *supraclavicular,* portion of the plexus—are arranged as follows: the anterior branches of the fifth and sixth cervical nerves unite beyond the lateral border of the scalenus anterior muscle to form an *upper trunk;* the anterior branch of the seventh cervical nerve remains distinct as the *middle trunk;* the anterior branches of the eighth cervical and first thoracic nerves unite between the scalenus anterior and the scalenus medius muscles to form the *lower trunk.* The upper and middle trunks run above and parallel with the subclavian artery, but on a posterior plane, while the lower trunk passes behind the artery. The three trunks accompany the artery between the clavicle and the first rib on their way to the axilla. These three trunks separate above the clavicle into anterior and posterior divisions; the anterior division of the upper and middle trunks form the lateral cord, while the anterior division of the lower trunk continues as the medial cord; all the posterior divisions unite to form the posterior cord. (For a description of the plexus within the axilla, the *axillary,* or *infraclavicular,* portion of the plexus see Dissection of Axilla p. 68.) The brachial plexus always seems difficult to remember. It would be simple if one thought of it as beginning with five nerves: the fifth, sixth, seventh and eighth cervicals and first thoracic; and ending in five nerves: the musculo-cutaneous, musculo-spiral (*radial*), medial, circumflex (*axillary*), and ulnar. The intermediate portion is divided into sets of three's, first as trunks and then as cords.

The **branches of the brachial plexus** are divided into two sets: those given off from the *supraclavicular,* and those from the *infraclavicular* portion of the plexus. The *supraclavicular branches* are the nerves to the subclavius, the rhomboidei, the scaleni and the longus colli muscles, the long thoracic nerve, the external respiratory nerve of Bell, communicating, and suprascapular nerves.

The **nerve to the subclavius muscle** arises from the trunk formed by the fifth and sixth cervical nerves, and passes downward over the third portion of the subclavian artery to the under surface of the subclavius muscle. It is frequently connected with the phrenic nerve at the lower part of the neck by a filament which passes in front of the subclavian vein.

The **nerve to the rhomboidei muscles** (**dorsalis scapulæ**) arises from the fifth cervical nerve, pierces the scalenus medius muscle, and passes backward beneath the levator anguli scapulæ (*levator scapulæ*) to the under surface of the rhomboidei, all of which muscles it supplies. It accompanies the posterior scapular (*descending branch of transverse cervical*) artery.

The **nerves to the scaleni and longus colli muscles** arise from the lower three cervical nerves near the intervertebral foramina.

The **long thoracic nerve,** the external respiratory nerve of Bell, arises within the substance of the scalenus medius muscle from the fifth, sixth, and seventh

cervical nerves. The first two roots pierce the scalenus medius below the nerve to the rhomboidei muscles, and the last root passes in front of the scalenus medius muscle. The long thoracic nerve passes downward behind the trunks of the brachial plexus and the subclavian vessels, and enters the axilla by way of the apex. Here it lies upon the serratus magnus (*serratus anterior*) muscle, which it supplies.

The **communicating branch to the phrenic nerve** arises from the fifth cervical nerve and joins the phrenic nerve on the scalenus anterior muscle. This nerve is sometimes absent, its place then being taken by the nerve to the subclavius muscle.

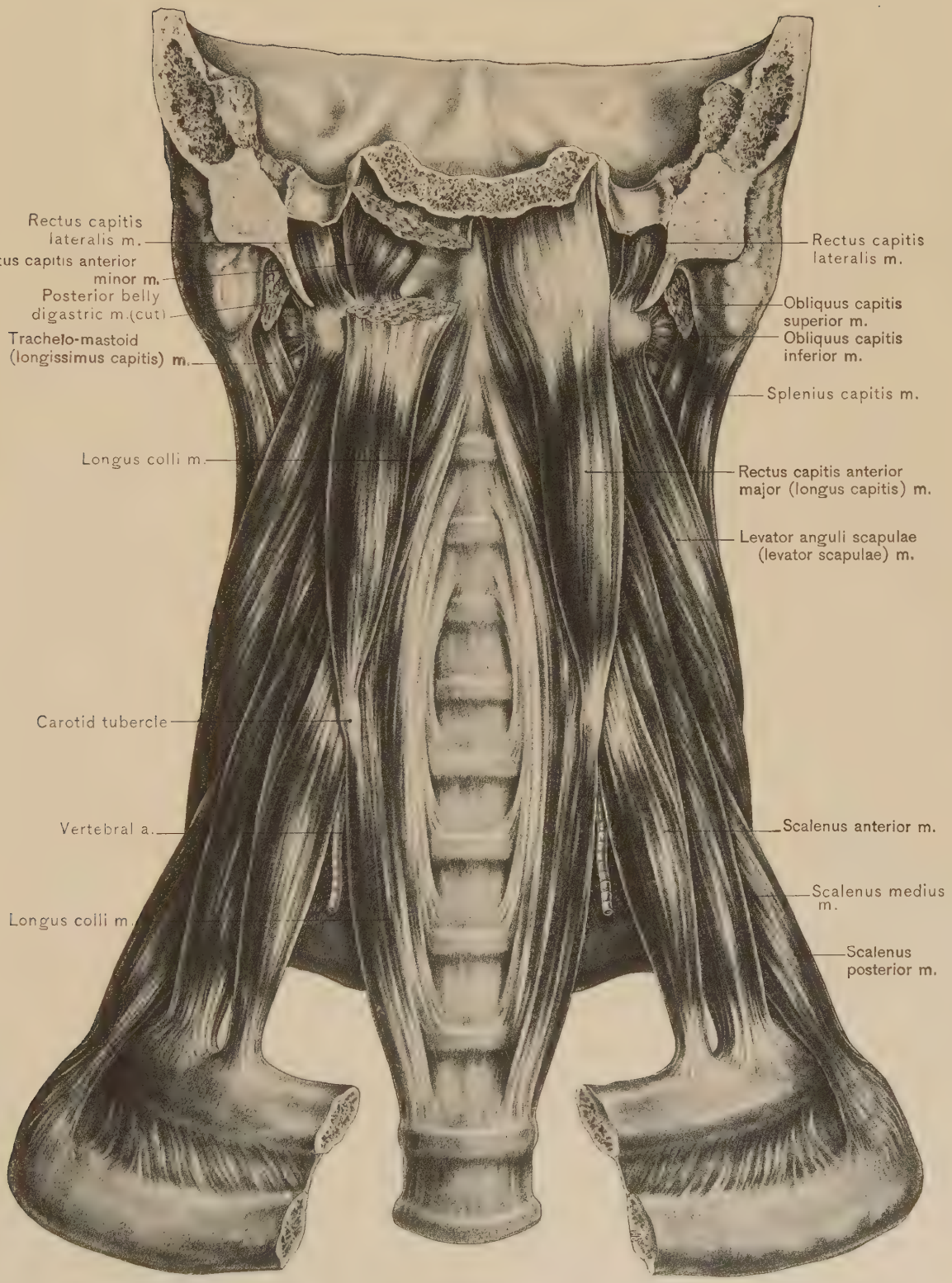
The **suprascapular nerve,** the largest of the supraclavicular branches, arises from the upper cervical trunk near the nerve to the subclavius muscle. It passes downward and lateralward beneath the trapezius and the posterior belly of the omo-hyoid muscle to the upper border of the scapula, where it is in relation with the suprascapular (*transverse scapular*) artery. It passes through the suprascapular (*small scapular*) notch, being separated from the artery by the transverse ligament, and enters the supraspinous fossa. It supplies the supraspinatus muscle, winds around the base of the spine of the scapula, and sends articular branches to the shoulder-joint, after which it terminates in the infraspinatus muscle.

Injuries to the plexus in the neck are frequently seen. Following a severe fall, the roots may be torn loose from their connection with the cord, a condition which is irremediable. Tumors of the neck pressing on the brachial plexus may give rise to both motor and sensory phenomena.

The Scaleni Muscles.—The scaleni muscles are: the anterior, the middle, and the posterior.

The **scalenus anterior muscle** (Plate CCLXIV) *arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ, and is *inserted* into the scalene tubercle on the medial border and upper surface of the first rib in front of the groove for the subclavian artery. In relation with its anterior surface are: the phrenic and vagus nerves, the transverse cervical, suprascapular (*transverse scapular*), and ascending cervical arteries, the internal jugular and subclavian veins, the subclavius and omo-hyoid muscles, and the clavicular head of the sterno-mastoid muscle. On the left side the thoracic duct crosses in front of the muscle. Along the medial border of the muscle, above, lies the rectus capitis anterior major (*longus capitis*) muscle; along the medial side of the lower part of the muscle lie the vertebral artery and vein, the inferior thyroid artery and cervical sympathetic which separate it from the longus colli muscle. Behind the scalenus anterior muscle are the pleura, the subclavian and superior intercostal (*costo-cervical trunk*) arteries, the nerves forming the brachial plexus, and the scalenus medius muscle.

PLATE CCLXIV.



PREVERTEBRAL MUSCLES.

Nerve Supply.—From the anterior primary branches of the fourth, fifth, and sixth cervical nerves.

Action.—The scalenus anterior muscle, when acting from its points of origin, raises the first rib; but if the rib is fixed, the muscle acting from below flexes the lower cervical vertebræ, at the same time slightly rotating these vertebræ.

The **scalenus medius muscle,** the largest, as well as the longest, of the three scalene muscles, *arises* from the posterior tubercles of the transverse processes of the lower six cervical vertebræ, and is *inserted* into the upper surface of the first rib, behind the groove for the subclavian artery. It is separated from the scalenus anterior muscle by the subclavian artery and the nerves forming the brachial plexus. Passing through its substance is the long thoracic nerve, the external respiratory nerve of Bell. It is in relation, in front, with the cervical and brachial plexuses of nerves, the subclavian artery, the scalenus anterior, omo-hyoid, and sterno-mastoid muscles, and the clavicle; along its lateral border, with the levator anguli scapulæ (*levator scapulæ*) and scalenus posterior muscles; behind, with a part of the scalenus posterior and the deep lateral muscles of the back of the neck.

Nerve Supply.—From branches of the anterior divisions of the cervical nerves.

Action.—When acting from above, the scalenus medius muscle elevates the first rib; with the rib fixed, it flexes the cervical portion of the spinal column laterally.

The **scalenus posterior muscle,** the smallest and deepest of the three scaleni, *arises* from the posterior tubercles of the transverse processes of the lower two or three cervical vertebræ, and is *inserted* into the lateral surface of the second rib behind the origin of the serratus magnus (*serratus anterior*) muscle. It is sometimes blended with the scalenus medius muscle.

Nerve Supply.—From the anterior divisions of the lower three cervical nerves.

Action.—When acting from below, it bends the neck laterally; when acting from above, it raises the second rib.

The scaleni are accessory muscles of respiration; this can be demonstrated by taking a full breath, and placing the fingers over these muscles when they will be felt contracting.

The scalene tubercle, or the tubercle on the first rib to which the scalenus anterior muscle is attached, is an important guide in locating the lateral edge of the muscle and the third portion of the subclavian artery. Immediately to the lateral side of the tubercle the subclavian artery can be compressed against the first rib. The position of the phrenic nerve on the scalenus anterior muscle, and the relation which the clavicular head of the sterno-mastoid muscle holds to the

phrenic nerve and scalenus anterior muscle must be borne in mind in operations upon the lower part of the side of the neck.

Dissection.—At the lower part of the neck divide the trachea, esophagus, common carotid artery, internal jugular vein, the vagus, sympathetic, and recurrent laryngeal nerves. Separate these structures from the prevertebral muscles with the fingers. In order to study the prevertebral muscles and the pharynx, divide the skull so as to leave its posterior portion attached to the prevertebral muscles and its anterior portion to the pharynx. Draw the pharynx well forward; while an assistant holds a weight or block against the upper surface of the basilar process of the occipital bone, divide that process between the attachments of the pharynx and the rectus capitis anterior major (*longus capitis*) muscle with a chisel and a mallet, the chisel being directed upward and backward. Next saw through the sides of the skull, so as to leave the jugular foramina and carotid canals in the anterior segment. Then with the chisel separate the petrous portion of the temporal bone from the basilar process; the two portions of the skull can now be separated with a knife, or by sawing from above downward just in front of the foramen magnum. The anterior portion of the skull, with the pharynx and larynx, should be kept moist while the prevertebral muscles are dissected.

The remainder of the prevertebral fascia should now be removed.

The **prevertebral muscles** (Plate CCLXIV) are the longus colli, rectus capitis anterior major (*longus capitis*), rectus capitis anterior minor (*rectus capitis anterior*), and rectus capitis lateralis.

The **longus colli muscle** consists of three sets of fibers: a longitudinal, a superior oblique, and an inferior oblique set. The *longitudinal set arises* from the bodies of the first, second, and third thoracic, and of the sixth and seventh cervical vertebræ, and passes upward to be *inserted* into the bodies of the second, third, and fourth cervical vertebræ. The *superior oblique set arises* from the anterior tubercles of the transverse processes of the third, fourth, and fifth cervical vertebræ, and passes upward and medialward to be *inserted* into the anterior tubercle of the atlas. The *inferior oblique set arises* from the bodies of the first, second, and third thoracic vertebræ, and passes upward and lateralward to be *inserted* into the anterior tubercles of the transverse processes of the fifth and sixth cervical vertebræ.

Lying in front of the longus colli muscle are: the prevertebral fascia, the pharynx, the esophagus, the cervical sympathetic, the inferior thyroid artery, the recurrent laryngeal nerve, and the carotid sheath, containing the vagus nerve, the common carotid artery, and the internal jugular vein. Behind the muscle are the cervical and upper thoracic vertebræ and the vertebral artery.

Below, the vertebral artery lies along the lateral border of the muscle, in the groove between it and the scalenus anterior muscle.

NERVE SUPPLY.—From the anterior branches of the second, third, and fourth cervical nerves.

ACTION.—It flexes the cervical portion of the spinal column, slightly flexes it laterally, and rotates it.

The **rectus capitis anterior major** (**longus capitis**) **muscle** *arises* from the anterior tubercles of the third, fourth, fifth, and sixth cervical vertebræ by four tendinous slips; these slips pass upward and medialward to the belly of the muscle, which is *inserted* into the basilar process of the occipital bone by a short tendon.

In front of the muscle are: the prevertebral fascia, the common and internal carotid arteries, the internal jugular vein, the vagus and cervical sympathetic nerves, and a portion of the pharynx. Behind it are the rectus capitis anterior minor (*rectus capitis anterior*) muscle, part of the longus colli muscle, and the upper cervical vertebræ.

NERVE SUPPLY.—From the anterior divisions of the first, second, and third cervical nerves.

ACTION.—It flexes the head and rotates the face to the same side.

DISSECTION.—Divide the rectus capitis anterior major (*longus capitis*) muscle near the basilar process and reflect it downward to expose the rectus capitis anterior minor (*rectus capitis anterior*) muscle.

The **rectus capitis anterior minor** (**rectus capitis anterior**) **muscle** *arises* from the anterior part of the lateral mass and the root of the transverse process of the atlas. Its fibers pass upward and medialward to be *inserted* into the basilar process of the occipital bone, between the foramen magnum and the insertion of the rectus capitis anterior major (*longus capitis*) muscle, which lies in front of it. Behind it is the occipito-atlantal (*atlo-occipital*) joint.

NERVE SUPPLY.—From the first cervical (suboccipital) nerve.

ACTION.—It flexes the head.

The **rectus capitis lateralis muscle** is seen to the lateral side of, and slightly posterior to the rectus capitis anterior minor (*rectus capitis anterior*). It *arises* from the upper surface of the transverse process of the atlas, and is *inserted* into the lower surface of the jugular process of the occipital bone.

In front of it are the internal jugular vein and the anterior branch of the first cervical nerve, and behind it are the trachelo-mastoid (*longissimus capitis*) muscle and the vertebral artery. The occipital artery lies on its lateral side.

NERVE SUPPLY.—From the anterior branch of the first cervical nerve.

ACTION.—It flexes the head laterally.

There are three **bursæ** in the neck: one in front of the upper part of the thyroid cartilage, or *pomum Adami;* another, *the thyro-hyoid bursa,* between the upper margin of the thyroid cartilage and the posterior surface of the hyoid bone; a third, situated near the median line, between the genio-hyoid and genio-glossus muscles. These bursæ may become enlarged; the one beneath the genio-hyoid muscle, when distended, may simulate a ranula. Like goiters and cysts of the thyroid gland, they move with the larynx in deglutition, differing in this respect from sebaceous and dermoid cysts, aneurysms of the carotid arteries, and growths of the lymph glands.

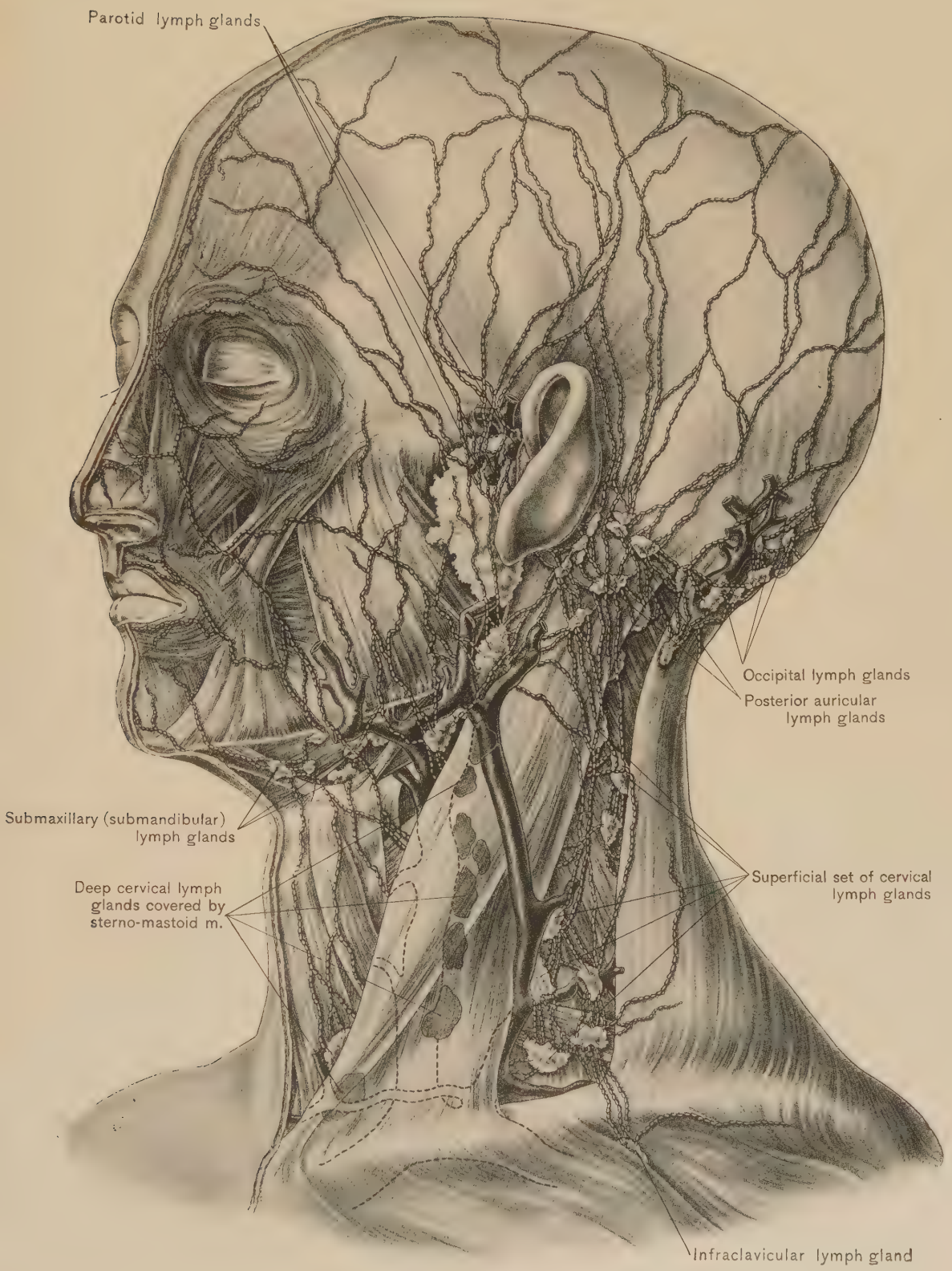
THE LYMPH GLANDS OF THE NECK

The lymph glands of the neck are classified as superficial and deep.

The **Superficial Lymph Glands** (Plate CCLXV) of the neck are most numerous along the course of the external jugular and posterior jugular veins. This set, the **superficial cervical chain,** consists of from four to six glands lying beneath the superficial layer of the deep cervical fascia in the posterior triangle, and found chiefly along the posterior surface of the sterno-mastoid muscle. Other small superficial lymph glands, *the anterior cervical nodes,* are seen in the median line of the neck: one below the symphysis of the mandible, two above the body of the hyoid bone, one near the cricoid cartilage, one above the sternum, and some resting upon the lateral sides of the trachea. Several of the latter are arranged in a chain and follow the recurrent laryngeal nerve. They are therefore frequently spoken of as the recurrential nodes. The superficial cervical chain receives *afferent* vessels from the suboccipital and posterior auricular lymph glands and some from the parotid and submaxillary lymph glands, and the lymph vessels from the external ear and skin of the neck. Their *efferent* vessels empty into the inferior deep cervical glands. The lowest of the superficial cervical lymph glands also receive lymph vessels from the infraclavicular glands which are situated in the upper part of the delto-pectoral sulcus. In secondary syphilis the superficial cervical lymph glands along the posterior border of the sterno-mastoid muscle are enlarged early and can readily be felt. The superficial nodes are much more inconstant than the deep nodes.

The **Deep Lymph Glands** of the neck number from twenty to thirty, and are situated along the internal jugular and subclavian veins. They are divided into a superior and an inferior set. The *superior set,* which varies from ten to sixteen in number, is situated along the internal jugular vein, between the base of the skull and the bifurcation of the common carotid artery. These glands receive their *afferent* vessels from the internal maxillary (*deep facial*) lymph glands, and some from the submaxillary lymph glands, the lymph vessels from

PLATE CCLXV.


Parotid lymph glands
Occipital lymph glands
Posterior auricular lymph glands
Submaxillary (submandibular) lymph glands
Deep cervical lymph glands covered by sterno-mastoid m.
Superficial set of cervical lymph glands
Infraclavicular lymph gland

LYMPH GLANDS AND LYMPH VESSELS.

the cranial cavity, the deep muscles of the upper part of the neck, the posterior part of the tongue, the middle portion of the pharynx, the upper part of the larynx, and the upper part of the thyroid body. Their *efferent* vessels empty into the glands of the inferior set. The *inferior set*, also called the supraclavicular (*lower deep cervical*) nodes, is situated along the internal jugular vein, below the bifurcation of the common carotid artery, and extends lateralward into the subclavian triangle along the subclavian vein. These glands receive their *afferent* vessels from the superior deep cervical and the superficial cervical glands; the lymph vessels from the lower part of the thyroid body, the lower part of the larynx, lower part of the pharynx, upper part of the trachea and esophagus, and lower part of the neck; and some of the lymph vessels from the axillary and infraclavicular glands. Their *efferent* vessels unite to form the jugular lymph trunk, which empties into the right lymph duct on the right side, and into the arch of the thoracic duct on the left side. Both the right and left trunks may empty directly into the subclavian vein.

The *superficial set* is enlarged in diseases of the external ear, the face, and the skin of the neck, and after involvement of the suboccipital, mastoid (*posterior auricular*), parotid, or submaxillary lymph glands.

The *deep cervical* lymph glands are more important surgically than the superficial ones. These deep glands hold so close a relation to the great vessels of the neck that an attempt to remove them when they are much enlarged may lead the operator into dangerous locations. The deep nodes are involved in lesions of the scalp, face, teeth, tonsils, pharynx, insides of the cheeks, otitis media, etc. They are also frequently involved in tuberculous adenitis, Hodgkin's disease, lympho-sarcoma, and metastatic carcinoma.

It should be borne in mind that the submental nodes on each side communicate, and thus allow metastasis to occur in the opposite side of the neck from that of the cancerous lesion in the mouth.

In the radical operation for excision of the mammary gland for carcinoma the lymph glands in the subclavian triangle should be excised in order to be sure that all metastatic foci are removed.

The *right lymph duct* is a short trunk about twelve millimeters (one-half inch) in length. It receives the lymph vessels from the right side of the neck, the right upper extremity, the right side of the thorax, and the upper surface of the liver. It empties into the subclavian vein or into the internal jugular vein at the junction of these veins. Its orifice is guarded by a double valve.

The *thoracic duct* (described with the contents of the thorax, Vol. III), receives the lymph vessels from about three-fourths of the body: from the left side of the head, neck, and thorax, the left upper extremity, the abdomen, and

the lower extremities. In the neck it is found only on the left side. It emerges from the upper opening of the thorax posterior and medial to the apex of the left pleural sac, curves anteriorly and lateralward above the first portion of the left subclavian artery and in front of the left vertebral artery, and empties into the left subclavian vein or the left internal jugular vein near the angle of junction of these veins. The thoracic duct near its termination may subdivide into two or more ducts; it occasionally empties into the right subclavian vein.

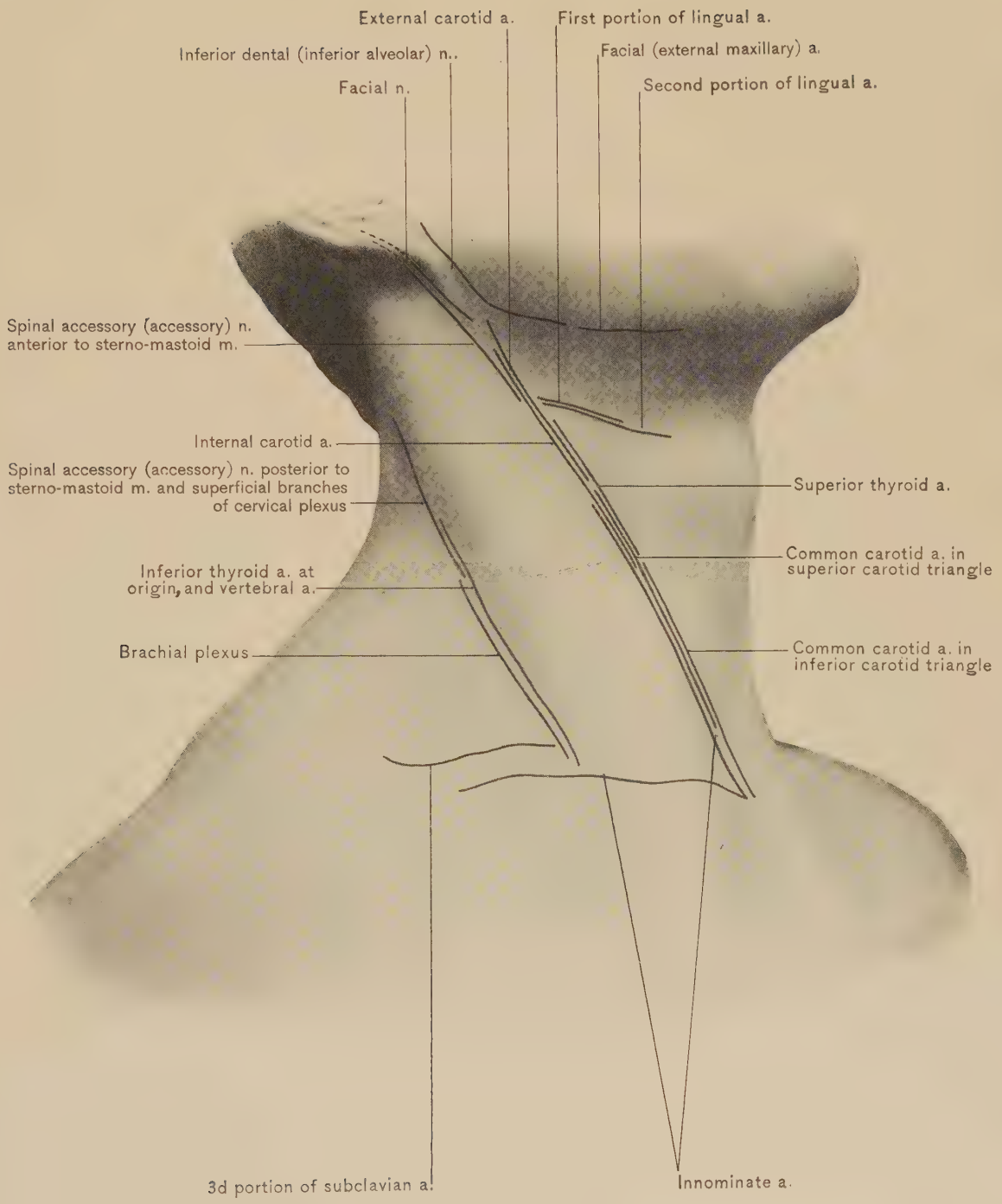
LIGATION OF ARTERIES OF HEAD AND NECK (Plate CCLXVI)

The **innominate artery** is ligated for aneurysm of the subclavian or of the common carotid artery. The operation is used as a last resort, since it is attended by a mortality of from thirty to fifty per cent. Death usually results from secondary hemorrhage occurring on the distal side of the ligature. The danger of the operation is somewhat reduced by ligating the common carotid and vertebral arteries, in addition to the innominate.

Relations.—In front of the innominate artery are: the sternum, right sterno-clavicular joint, sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland. The left innominate vein crosses it at its origin, and the right inferior thyroid vein descends obliquely over its lower and medial part. Behind it are the trachea and the right pleura. To its right side are the right innominate vein, right vagus nerve, and pleura. To its left side are the inferior thyroid veins, left common carotid artery, remains of the thymus gland, and, at its upper end, the trachea. The innominate artery usually divides at the upper border of the right sterno-clavicular articulation; occasionally it may divide lower, but seldom higher.

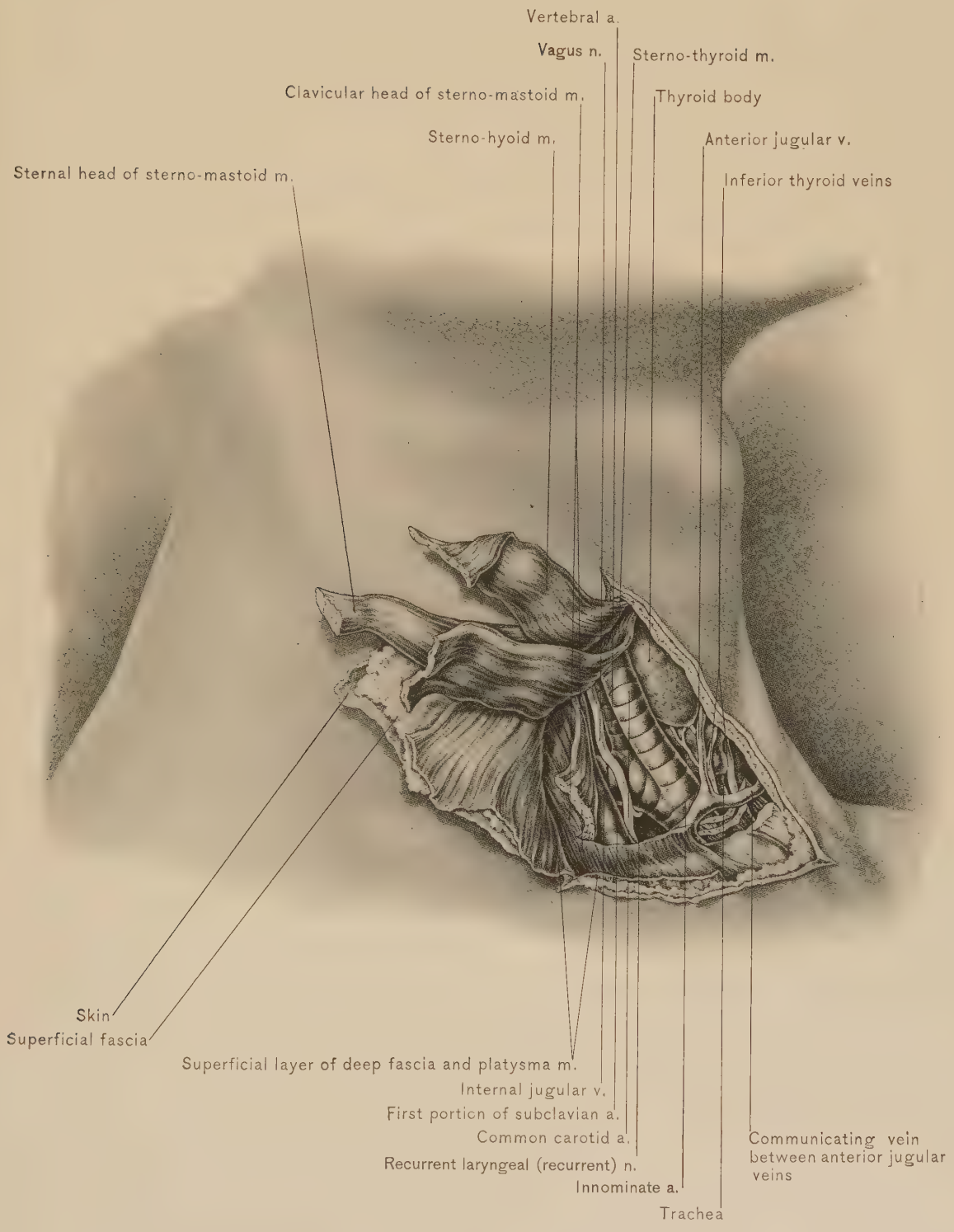
Ligation.—Its depth and relation to important and delicate structures render its ligation difficult. The incision should be carried along the anterior border of the right sterno-mastoid muscle to the upper margin of the sternum, and thence along the right clavicle. An angular incision is thus made, each part of which should be about eight centimeters (three inches) in length (Plate CCLXVII). The superficial incision divides the skin, superficial fascia, platysma muscle, and the suprasternal and supraclavicular branches of the cervical plexus. The triangular flap of skin, the superficial fascia, and the platysma muscle should next be turned upward. The superficial layer of the deep fascia, sterno-hyoid, sterno-thyroid, and inner part of the sterno-mastoid muscle are next divided. The anterior jugular vein, which may require division between ligatures, runs transversely under the lower end of the sterno-mastoid muscle. The sheath of the common carotid artery should be opened and the artery traced downward to the innominate artery. The aneurysm needle, directed slightly downward,

PLATE CCLXVI.


External carotid a.
First portion of lingual a.
Inferior dental (inferior alveolar) n.
Facial (external maxillary) a.
Facial n.
Second portion of lingual a.
Spinal accessory (accessory) n. anterior to sterno-mastoid m.
Internal carotid a.
Spinal accessory (accessory) n. posterior to sterno-mastoid m. and superficial branches of cervical plexus
Superior thyroid a.
Common carotid a. in superior carotid triangle
Inferior thyroid a. at origin, and vertebral a.
Brachial plexus
Common carotid a. in inferior carotid triangle
3d portion of subclavian a.
Innominate a.

LINES OF INCISION FOR EXPOSURE OF ARTERIES AND NERVES OF NECK.

PLATE CCLXVII.



EXPOSURE OF INNOMINATE ARTERY.

should be carefully passed around the artery, from without medialward. In doing this, great care must be taken to avoid puncturing the innominate vein and the pleura.

Collateral Circulation.—The collateral circulation is established by the following anastomoses:

Proximal		Distal
Aortic intercostal arteries	with	Superior intercostal artery (*costo-cervical trunk*). Internal mammary artery. Superior thoracic artery. Long thoracic artery. Subscapular artery. Posterior scapular (*descending branch of transverse cervical*) artery.
Inferior phrenic branch of the abdominal aorta	with	Musculo-phrenic branch of internal mammary artery.
Deep epigastric artery	with	Superior epigastric branch of the internal mammary artery.
Thyroidea ima artery	with	Superior thyroid artery. Inferior thyroid artery.
Vertebral arteries Internal carotids of left circle of Willis (*circulus arteriosus*))	with	Vessels in right half of circle of Willis (*circulus arteriosus*).
Branches of left external carotid	with	Branches of right external carotid.

Irregular Forms.—The innominate artery may bifurcate higher or lower than the upper margin of the right sterno-clavicular articulation; it may give off the thyroidea ima, the vertebral, or the internal mammary artery, a thymic, a tracheal, a bronchial, or a pericardial branch, and it may arise as the third branch of the transverse portion of the arch of the aorta. When the innominate artery bifurcates at an unusually high level, it can be tied more readily, and may overlie the trachea for two and a half centimeters above the sternum and be endangered in the low operation for tracheotomy; if it divides at a lower level, it is tied with difficulty. When the innominate artery is the last branch of the transverse portion of the arch of the aorta, it may pass behind the trachea and the esophagus. An innominate artery rarely exists on the left side, or the innominate artery may be altogether absent, and the right common carotid and the right subclavian artery may arise from the arch of the aorta.

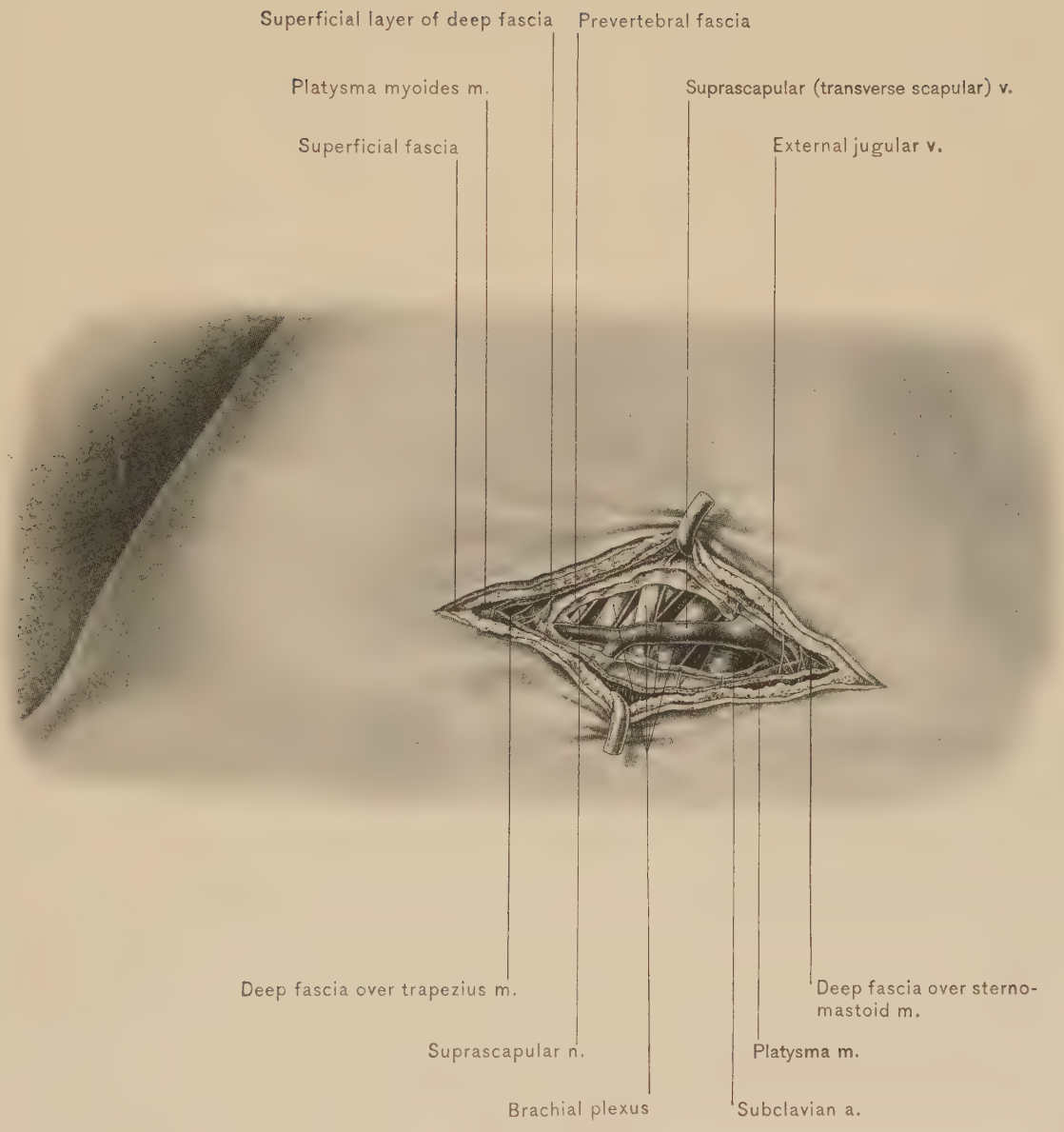
Guides.—The guides to the innominate artery are the right sterno-clavicular articulation, the right common carotid artery, and the angle between the roots of the right common carotid and the right subclavian artery.

The **subclavian artery** is usually tied in its third portion, which is to the lateral side of the anterior scalene muscle, and is the place of election. Ligation of the *first portion* of the artery is attended with great risk and generally results disastrously because this portion of the artery is deeply placed, and is closely associated with the vagus and cervical sympathetic nerves and their cardiac branches, with the pleura behind and the commencement of the innominate vein or the termination of the internal jugular vein in front of the first portion. The *second portion* is seldom tied, the artery being here covered by the scalenus anterior muscle, which underlies the phrenic nerve and is also closely related to the pleura.

The *third portion* (Plate CCLXVIII) of the subclavian artery is more accessible, being more superficial and not so closely associated with important structures. It is ligated for aneurysm of the arch of the aorta and of the innominate and the axillary arteries; also previous to excision of the scapula, amputation at the shoulder-joint, and removal of large growths from the axilla. It is covered by skin, superficial fascia, the platysma muscle, supraclavicular branches of the cervical plexus, superficial layer of the deep cervical fascia, areolar tissue and fat, which here contains the terminations of the external jugular vein and suprascapular (*transverse scapular*) vein, and, at times, the posterior external jugular, transverse cervical colli, and jugulo-cephalic veins. When all of these veins are present in this location, they form a plexus over the artery and increase the difficulty of reaching the vessel. The third portion of the artery is also covered by the prevertebral fascia, or the posterior process of the deep cervical fascia, and is crossed anteriorly by the subclavius muscle. The suprascapular (*transverse scapular*) artery and vein cross this portion of the artery from within lateralward, and usually lie near the level of the upper border of the clavicle. In this respect the suprascapular (*transverse scapular*) artery bears the same relation to the subclavian artery at the point of election as the middle sterno-mastoid artery to the common carotid artery at its point of election. Behind this part of the subclavian artery are the scalenus medius muscle, the first rib, and the lower cervical trunk of the brachial plexus, which is formed by the eighth cervical and the first thoracic nerve. Above it are the upper and intermediate trunks of the brachial plexus and the posterior belly of the omo-hyoid muscle. The upper cervical trunk of the brachial plexus, which lies just above the artery and in an anterior plane, may be mistaken for the subclavian artery. Below, it rests against the upper surface of the first rib. The subclavian vein lies below the subclavian artery, but on an anterior plane, and is usually behind the clavicle.

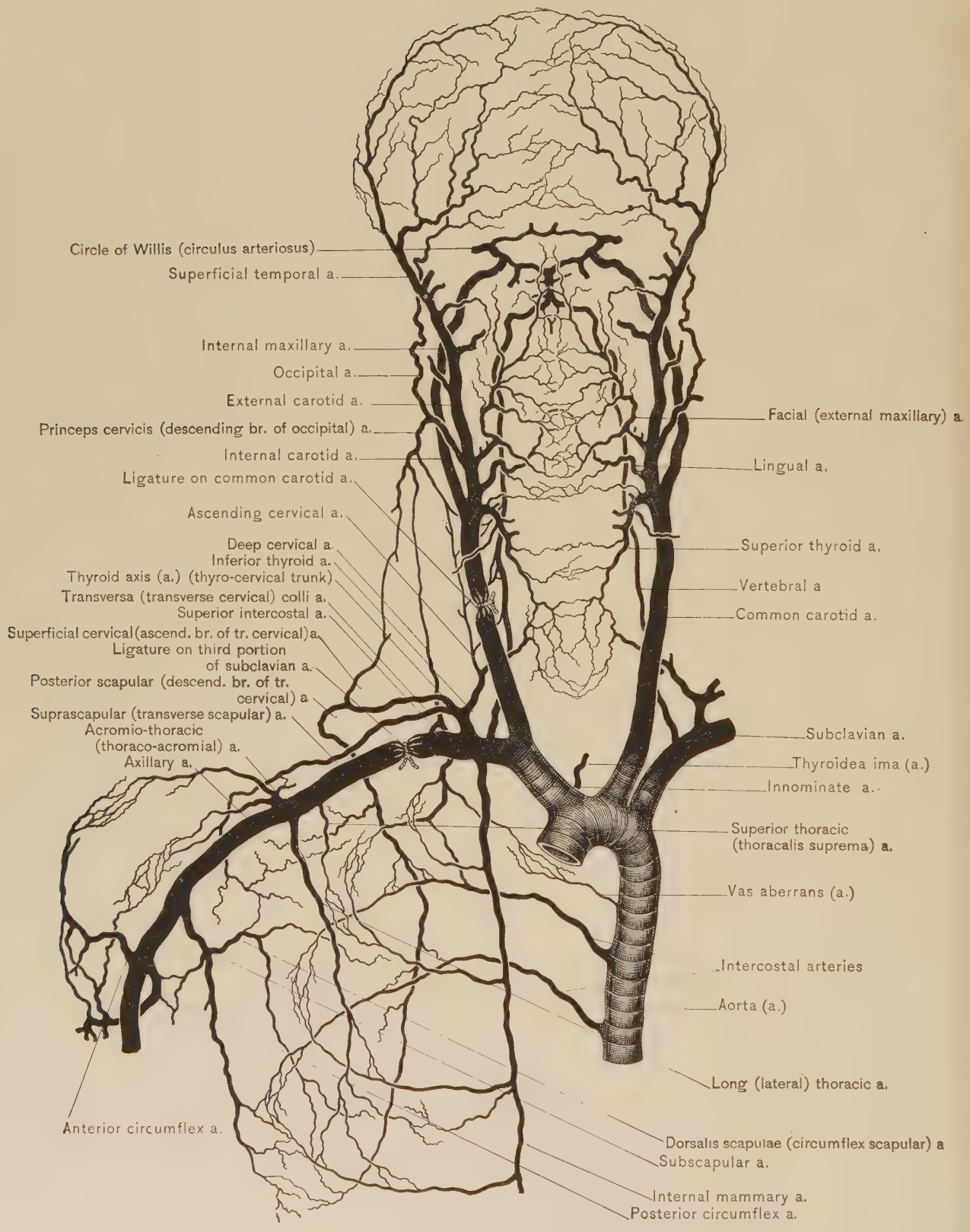
In ligating the third portion of the subclavian artery the upper part of the thorax should be elevated by placing a pillow beneath the shoulders; the neck

PLATE CCLXVIII.



EXPOSURE OF THIRD PORTION OF SUBCLAVIAN ARTERY.

PLATE CCLXIX.



COLLATERAL CIRCULATION AFTER LIGATION OF SUBCLAVIAN AND COMMON CAROTID ARTERIES.

should be extended, and the head turned toward the opposite side. The shoulder is next depressed, to make the subclavian triangle shallow and to bring the artery nearer to the surface. The skin should be drawn downward over the clavicle, and a transverse incision, eight centimeters (three inches) long, should be carried along that bone, so that when the skin is allowed to retract, the incision will be about twelve millimeters (one-half inch) above the clavicle. This method of dividing the skin obviates the danger of injuring the external jugular vein, which crosses the artery close to or under the posterior border of the sterno-mastoid muscle. The incision should extend from the trapezius to the sterno-mastoid muscle. It divides the skin, superficial fascia, platysma muscle, supraclavicular branches of the cervical plexus, some small arteries, and the jugulo-cephalic vein, if present. The superficial layer of the deep fascia is next divided. If a plexus of veins is present, the veins should be divided between ligatures, and the posterior process of the deep fascia, the prevertebral fascia, carefully incised. The posterior belly of the omo-hyoid muscle is located, and the posterior border of the scalenus anterior muscle is found, and traced downward to the scalene tubercle of the first rib. The artery, which may be felt pulsating just lateral to the tubercle, is exposed, together with the cervical trunks of the brachial plexus, by a slight dissection. The sheath of the artery being opened, the aneurysm needle is passed backward around the artery from below upward, to avoid the subclavian vein, which lies below, but in an anterior plane. The needle should be held close to the artery to avoid inclusion of the lowest trunk of the brachial plexus, which lies behind the artery. The transverse cervical artery is rarely seen, owing to its high position, while the suprascapular (*transverse scapular*) artery crosses the subclavian just behind the clavicle. If either artery is seen, it should be displaced, and not divided; if the external jugular vein causes much difficulty, it should be divided between ligatures. In very muscular subjects it may be necessary to cut through the posterior part of the clavicular origin of the sterno-mastoid muscle. The variations in the position of this portion of the artery should be borne in mind. It usually emerges from beneath the scalenus anterior muscle, about twelve millimeters above the clavicle, and descends abruptly; it may, however, lie almost entirely under the clavicle, or it may ascend as high as four centimeters (one and a half inches) above the clavicle. It occasionally gives origin to the posterior scapular (*descending branch of transverse cervical*) artery. The absence of pulsation beyond the ligature indicates that the ligature has been applied to the subclavian artery instead of to a trunk of the brachial plexus.

The Collateral Circulation (Plate CCLXIX) is established by the following anastomoses—

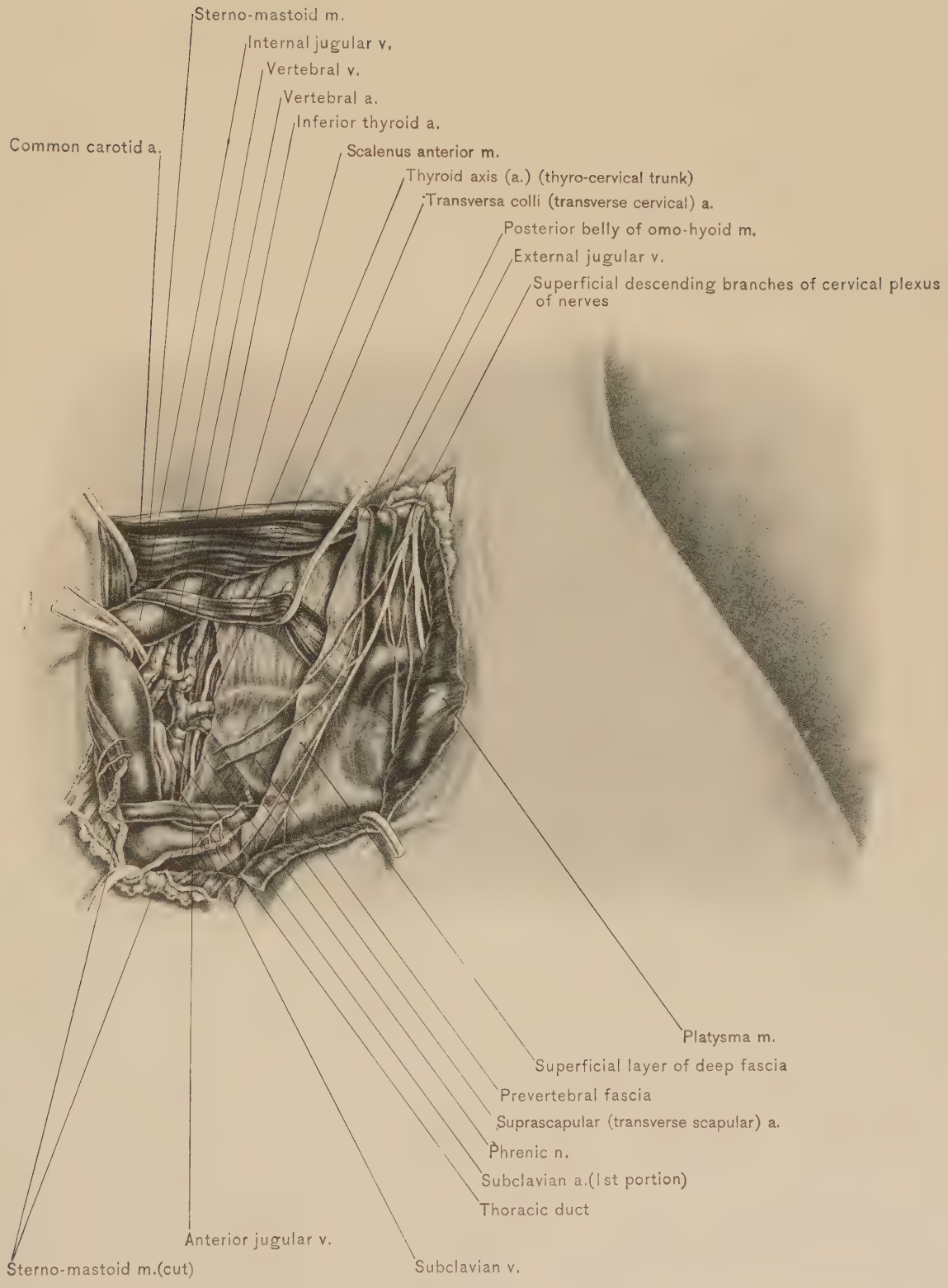
Above		Below
Suprascapular (*transverse scapular*) and Posterior scapular (*descending branch of transverse cervical*) arteries	with	Acromio-thoracic, posterior circumflex, and subscapular arteries.
Internal mammary artery Superior intercostal artery (*costo-cervical trunk*) Aortic intercostal artery	with	Superior thoracic (*thoracalis suprema*), long (*lateral*) thoracic, and subscapular arteries.

Irregular Forms.—The *right subclavian artery* may arise higher or lower than normally, or it may spring directly from the transverse portion of the arch of the aorta as the first, second, third, or fourth branch. When it is the first branch, the first portion takes the course of the innominate artery and is more deeply situated than normally; as the second or third branch, it usually passes under the common carotid artery; and as the fourth branch, it may pass either under or between the trachea and the esophagus, or it may arise from the descending portion of the aorta as low as the fourth thoracic vertebra. The *left subclavian artery* may arise from a short trunk common to it and the left common carotid artery. On each side the subclavian artery may pass in front of, or pierce the scalenus anterior muscle; the subclavian vein may accompany the second portion of the subclavian artery through or under the scalenus anterior muscle. The second portion may lie under the clavicle, or it may rise four centimeters (one and a half inches) above the clavicle. The third portion of the subclavian artery frequently gives origin to the posterior scapular (*descending branch of transverse cervical*), and occasionally to the suprascapular (*transverse scapular*) artery; in muscular persons it may be covered by the sterno-mastoid and trapezius muscles. A clavicular origin of the posterior belly of the omo-hyoid muscle may lie in front of this portion, and this belly of the omo-hyoid may lie close to the clavicle in front of the subclavian artery. The external jugular vein may cross the artery at some distance lateral to the posterior border of the sterno-mastoid muscle.

Guides.—The guides to the third portion of the subclavian artery (the place of election) are: the most prominent part of the clavicle behind which it lies, the posterior border of the sterno-mastoid muscle, the lateral border of the insertion of the scalenus anterior muscle into the scalene tubercle of the first rib, and the pulsations of the artery.

The **vertebral artery** (Plate CCLXX) may be ligated for wounds and for traumatic or spontaneous aneurysm of the innominate artery and arch of the aorta. Its only accessible portion is situated deep in the lower part of the neck, where

PLATE CCLXX.



EXPOSURE OF VERTEBRAL ARTERY AND INFERIOR THYROID ARTERY AT ORIGIN—LEFT SIDE OF NECK.

it lies in the groove between the scalenus anterior and the longus colli muscles. This portion of the artery is in relation in front with the vertebral and internal jugular veins, and is crossed on both sides by the inferior thyroid artery and by the thoracic duct on the left side. The vertebral vein crosses in front of the artery just below the transverse process of the sixth cervical vertebra; it then lies in front and to the lateral side of the artery as it passes downward to the innominate vein. The relation of the vertebral vein to the artery is variable, as the vein may be found on either side of the artery. Posterior to the artery are the cervical sympathetic cord, the inferior cervical sympathetic ganglion, and the transverse process of the seventh cervical vertebra. To its medial side is the longus colli muscle, and to its lateral side the scalenus anterior muscle. It is surrounded by the vertebral sympathetic plexus.

In the operation for ligation of the vertebral artery, the patient lies in the same position as for ligating the third portion of the subclavian artery—with the shoulder elevated, the neck extended, and the face turned to the opposite side. The incision should commence at the clavicle, and be carried eight centimeters (three inches) upward along the posterior border of the sterno-mastoid muscle.

Care is required here to avoid injuring the external jugular vein, which runs under the platysma muscle obliquely across the sterno-mastoid muscle to its posterior border, then along that border, piercing the superficial layer of the deep fascia twelve millimeters (one-half inch) above the clavicle. The incision divides the skin and superficial fascia, the platysma muscle and the descending branches of the cervical plexus. The external jugular vein is exposed and drawn lateralward, and the superficial layer of the deep fascia divided. It may be necessary to sever part of the clavicular head of the sterno-mastoid muscle at its origin. After locating the scalenus anterior muscle, the surgeon carries his finger medialward through the interval between the prevertebral fascia and the superficial layer of the deep fascia, to ascertain the positions of the internal jugular vein, the common carotid artery, and the transverse process of the sixth cervical vertebra. The carotid tubercle, or anterior tubercle of the transverse process of the sixth cervical vertebra, is the guide to the vertebral artery, since it is usually the first transverse process which is entered by the artery. Just below this tubercle the groove between the scalenus anterior and the longus colli muscles can be felt, and the prevertebral fascia is divided along the medial border of the scalenus anterior muscle. Along the medial border of the scalenus anterior, the inferior thyroid artery can be recognized by its pulsations, also the vertebral artery deep in the groove previously mentioned. The vertebral vein and the inferior thyroid artery should then be drawn lateralward, and the needle passed from without medialward. Care is necessary to avoid injuring the internal

jugular vein, the inferior thyroid artery, the vertebral vein, the pleura, the right lymphatic duct, and, on the left side, the thoracic duct. The phrenic nerve is not endangered because it lies beneath the prevertebral fascia on the scalenus anterior muscle. Immediately after the artery is tied contraction of the pupil of the same side occurs, due to disturbance of the vertebral plexus of the cervical sympathetic, showing that the inferior thyroid artery or its ascending cervical branch has not been tied instead of the vertebral artery.

Irregular Forms.—The left vertebral artery may arise from the subclavian at a point unusually near either the origin or the termination of the first portion of the left subclavian artery; or it may arise from the arch of the aorta, or from the left common carotid artery.

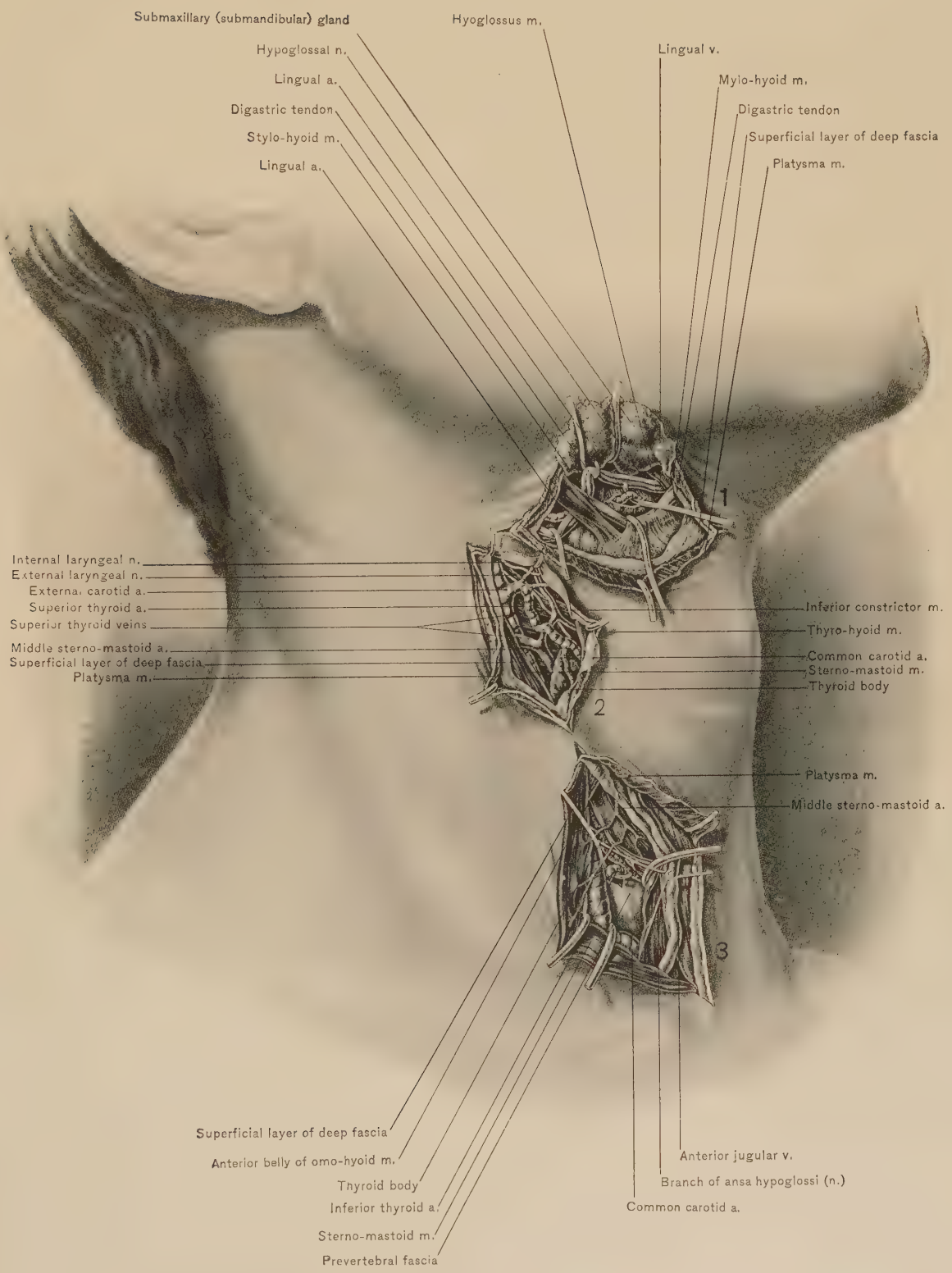
The right vertebral artery occasionally arises nearer the bifurcation of the innominate artery or to the medial margin of the scalenus anterior muscle. When the right subclavian artery arises from the aortic arch, the right vertebral artery may arise from the right common carotid artery or from the arch of the aorta; when it arises from the left side of the aortic arch, it may pass behind the esophagus.

Either vertebral artery may arise from the subclavian as two branches which later unite; or the vertebral artery may divide while passing upward in the transverse processes, one branch entering the spinal canal with the second cervical nerve, and the other pursuing the normal course of the vertebral artery. On each side the vertebral artery frequently enters the passageway in the cervical transverse processes, at some other than the sixth cervical transverse process. It may first enter any of the cervical transverse processes from the second to the seventh inclusive. When the artery first enters the seventh cervical transverse process its ligation is difficult, and when it enters above the sixth, the artery lies nearer to the esophagus than normally. The vertebral artery occasionally gives origin to the inferior thyroid, the superior intercostal (*costo-cervical trunk*), the profunda cervicalis, or the occipital artery. One vertebral artery may be larger than its fellow of the opposite side.

Guides.—The guides to the vertebral artery are the posterior border of the sterno-mastoid muscle and the carotid tubercle, or anterior tubercle of the sixth cervical transverse process, which lies at the upper extremity of the groove between the scalenus anterior and longus colli muscles.

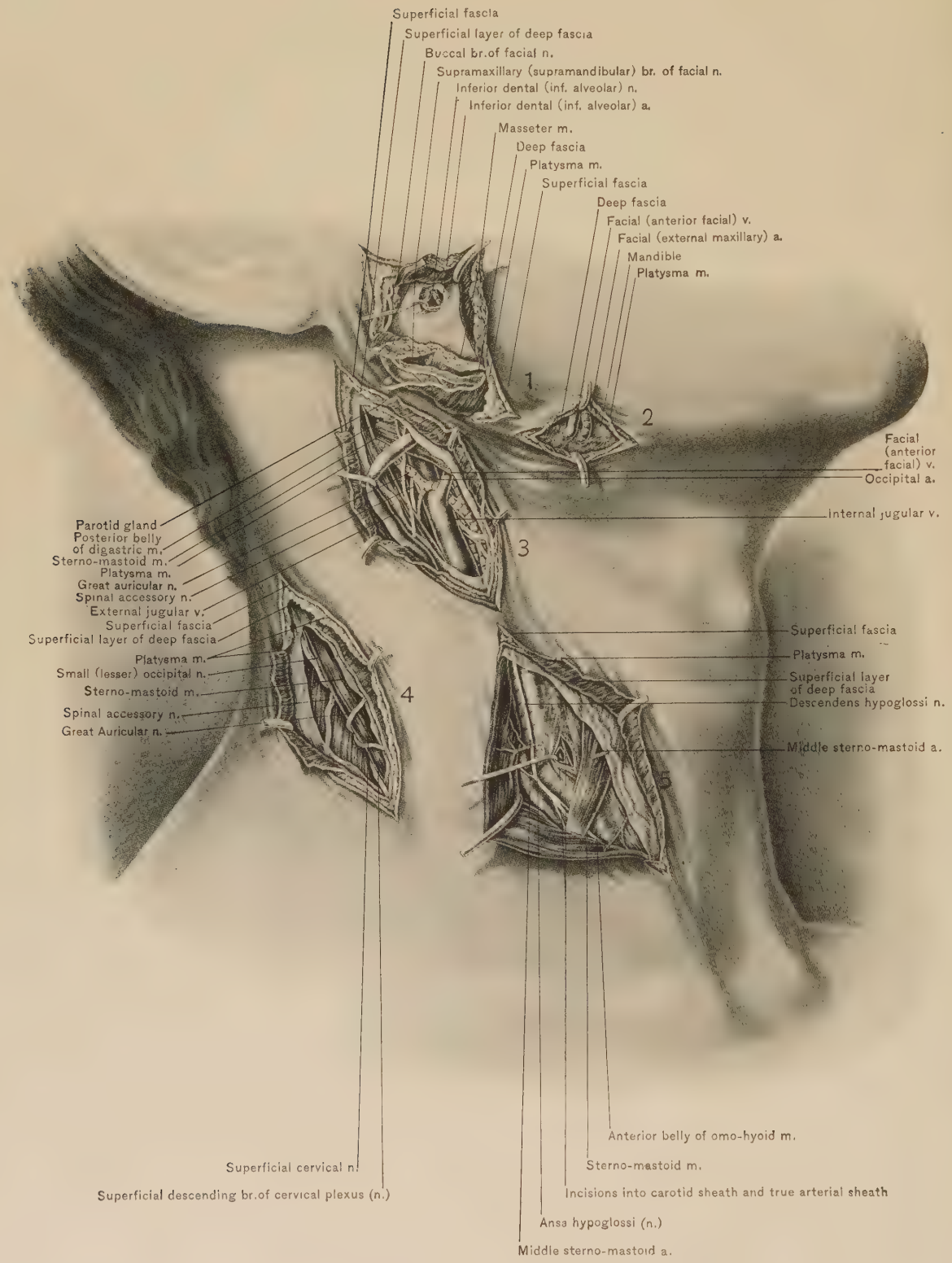
The **inferior thyroid artery** (Plate CCLXXI) is ligated for wounds of the thyroid gland, or to diminish the secretion of the thyroid body in toxic goiter, or, more commonly, in the operation of thyroidectomy. It may be tied near its origin, where it lies along the medial border of the scalenus anterior muscle, between that muscle and the internal jugular vein, or to the medial side of the

PLATE CCLXXI.



LIGATION OF (1) FIRST AND SECOND PORTIONS OF LINGUAL ARTERY; (2) SUPERIOR THYROID ARTERY; (3) INFERIOR THYROID ARTERY.

PLATE CCLXXII.



EXPOSURE OF (1) INFERIOR DENTAL NERVE; (2) FACIAL (EXT. MAXILLARY) ARTERY; (3, 4) SPINAL ACCESSORY (ACCESSORY) NERVE AND SUPERFICIAL BRANCHES OF CERVICAL PLEXUS; AND (5) COMMON CAROTID ARTERY IN SUPERIOR CAROTID TRIANGLE.

carotid sheath as it enters the thyroid gland. It is seldom ligated near its origin, where it may be secured through an incision similar to that made when ligating the vertebral artery. English surgeons ligate the inferior thyroid artery as a preliminary operation for hyperthyroidism. This operation, however, is rarely done in this country. To reach the artery just before it enters the thyroid gland, where it lies on or slightly below the level of the cricoid cartilage of the larynx, the shoulders should be elevated and the neck extended, and an incision eight centimeters (three inches) long be made along the lower portion of the anterior border of the sterno-mastoid muscle. The skin and superficial fascia, and the platysma muscle are divided, avoiding the anterior jugular vein; the superficial layer of the deep fascia is also divided. The sterno-mastoid muscle and the carotid sheath with its contents should be drawn lateralward and the sterno-hyoid and sterno-thyroid muscles and thyroid gland drawn medialward. Locate the carotid tubercle behind the carotid sheath, and the artery will be felt pulsating just below and medial to it. Next divide the prevertebral fascia. The artery should then be tied near the carotid sheath, thus avoiding injury of the recurrent laryngeal nerve; this nerve, however, is not in much danger, as in this location it lies posterior and medial to the lateral lobe of the thyroid gland. The inferior thyroid artery frequently divides behind the carotid sheath into two terminal branches of about equal size, which are separated by an interval of about six millimeters (one-fourth inch).

Irregularities.—The inferior thyroid artery occasionally arises directly from the first portion of the subclavian artery; it may also arise from the third portion near the lateral border of the scalenus anterior muscle, or from the vertebral or the common carotid artery. It may subdivide before it reaches the thyroid body, or it may arise as two separate arteries, one branch passing in front of and the other behind the carotid sheath. The artery may be small or altogether absent.

The **common carotid artery** (Plate CCLXXII) is ligated for aneurysm or wounds of the internal or external carotid arteries or their branches, to check malignant growths, and preparatory to the removal of tumors. It may be tied in any part of its course in the neck, which is indicated by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the mandible and the mastoid process of the temporal bone, the portion of this line below the level of the upper border of the thyroid cartilage indicating the course of the common carotid artery. On the right side the common carotid artery arises as one of the two terminal branches of the innominate artery, which divides behind the upper border of the right sterno-clavicular articulation; on the left side, however, it arises within the chest from the arch of the aorta. On both sides the

common carotid artery terminates opposite the upper border of the thyroid cartilage, where it divides into the external and internal carotid arteries.

In front of the artery are: the skin and superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the medial border of the sterno-mastoid muscle, the anterior jugular vein, the sterno-hyoid and sterno-thyroid muscles, the lateral lobe of the thyroid gland, the superior and middle thyroid veins, the middle sterno-mastoid artery, the omo-hyoid muscle, the descendens hypoglossi nerve,the ansa hypoglossi, and the anterior wall of the sheath. To its lateral side are the internal jugular vein and the vagus nerve. On the right side at the root of the neck the internal jugular vein passes lateralward away from the artery, while on the left side it overlaps the artery and curves forward to empty into the left innominate vein. Posteriorly and laterally is the vagus nerve, and posterior to it are the posterior wall of its sheath, the cervical sympathetic, the inferior thyroid artery, the recurrent laryngeal nerve, and the longus colli and the rectus capitis anterior major (*longus capitis*) muscles. To its medial side are: the medial wall of its sheath, the trachea, the esophagus, the recurrent laryngeal nerve, the lateral lobe of the thyroid gland, the cricoid and thyroid cartilages, the pharynx, the superior thyroid artery, and the external laryngeal branch of the superior laryngeal nerve.

The artery is usually tied in the superior carotid triangle, above the anterior belly of the omo-hyoid muscle, where it is more superficial. In the inferior carotid triangle, below the anterior belly of the omo-hyoid muscle, the artery is deeper, being covered by additional structures, the sterno-hyoid and sterno-thyroid muscles, and overlapped by the lateral lobe of the thyroid gland. The omo-hyoid muscle crosses the artery at the level of the cricoid cartilage, the middle thyroid vein crosses just above that muscle, and the superior thyroid vein and the middle sterno-mastoid artery cross the artery higher in the superior carotid triangle.

In the operation through the *superior carotid triangle* (Plate CCLXXII), the patient should rest upon the back, with the shoulders elevated, the neck extended, and the face turned slightly to the opposite side. The superficial veins should be located, especially the vein which connects the submental veins with the anterior jugular vein and runs beneath the platysma muscle parallel to, and along the medial side of the anterior border of the sterno-mastoid muscle. An incision eight centimeters (three inches) long should be made in the line of the artery, with the center of the incision on a level with the cricoid cartilage. Divide the skin and superficial fascia, the platysma muscle, the superficial vessels and nerves, and the superficial layer of the deep fascia, taking care to avoid the communicating branch between the anterior jugular and submental veins. The sterno-mastoid muscle should be displaced lateralward and the omo-hyoid muscle downward,

and the pulsations of the artery should be felt. The middle sterno-mastoid artery and the superior and middle thyroid veins should be avoided, if possible, and the internal jugular vein and descendens hypoglossi nerve should be avoided by opening the medial wall of the carotid sheath. By holding up first one edge of the opening in the sheath and then the other, the sheath can be gently separated from the artery with an aneurysm needle. The needle should be passed from without inward, threaded, and withdrawn.

To tie the common carotid artery in the *inferior carotid triangle*, the patient should be placed in the same position as for the higher ligation. The incision, which is about eight centimeters (three inches) in length, should be made along the anterior border of the sterno-mastoid muscle, beginning at the level of the cricoid cartilage, and extending almost to the sterno-clavicular articulation. The skin and superficial fascia, the platysma muscle, and the superficial vessels and nerves are divided. The anterior jugular vein and the vein which connects it with the facial or submental vein should be avoided. The superficial layer of the deep fascia is divided, the sterno-mastoid muscle drawn lateralward, and the sterno-hyoid and sterno-thyroid muscles, medialward. The sheath is opened on the lateral side, and the needle passed from without medialward. The structures which are to be avoided in the operation are: the anterior jugular vein; its tributary, which runs beneath the platysma muscle parallel with the anterior border of the sterno-mastoid muscle; the nerves from the ansa hypoglossi to the sterno-hyoid and sterno-thyroid muscles, the internal jugular vein, the inferior thyroid veins, the inferior thyroid artery, and the recurrent laryngeal nerve. On the left side the internal jugular vein overlaps the artery at the lower part of the neck and renders the operation more difficult.

Collateral Circulation.—The collateral circulation, after ligation of the common carotid artery, is established by the anastomoses of the following arteries:

Proximal Side		Distal Side
Branches of the external carotid artery of the opposite side	with	Branches of the external carotid artery of the same side.
Vertebral artery of same side and opposite internal carotid artery and vertebral artery	with	Internal carotid artery of the same side through circle of Willis (*circulus arteriosis*).
Inferior thyroid artery, thyroidea ima artery (if present)	with	Superior thyroid artery.
Ascending cervical artery Superficial cervical (*ascending branch of transverse cervical*) artery Deep cervical artery	with	Princeps cervicis (*descending branch of occipital*) artery.
Ascending cervical artery	with	Ascending pharyngeal artery.
Vertebral artery	with	Occipital artery.

The tissues supplied by the external carotid artery are chiefly nourished through the anastomoses between the opposite branches of the two external carotid arteries, and the portion of the brain previously nourished by the internal carotid artery receives its blood supply through the two vertebral arteries and the opposite internal carotid artery.

Irregularities.—The *right common carotid artery*, when the innominate artery is absent, may arise from the arch of the aorta separately or from a trunk common to the two common carotid arteries. When it arises from a trunk common to it and the left common carotid artery, it may cross in front of the trachea above the sternum. Owing to the variability in the level at which the innominate artery bifurcates, the right common carotid artery may arise higher or, more frequently, lower than the upper margin of the right sterno-clavicular joint.

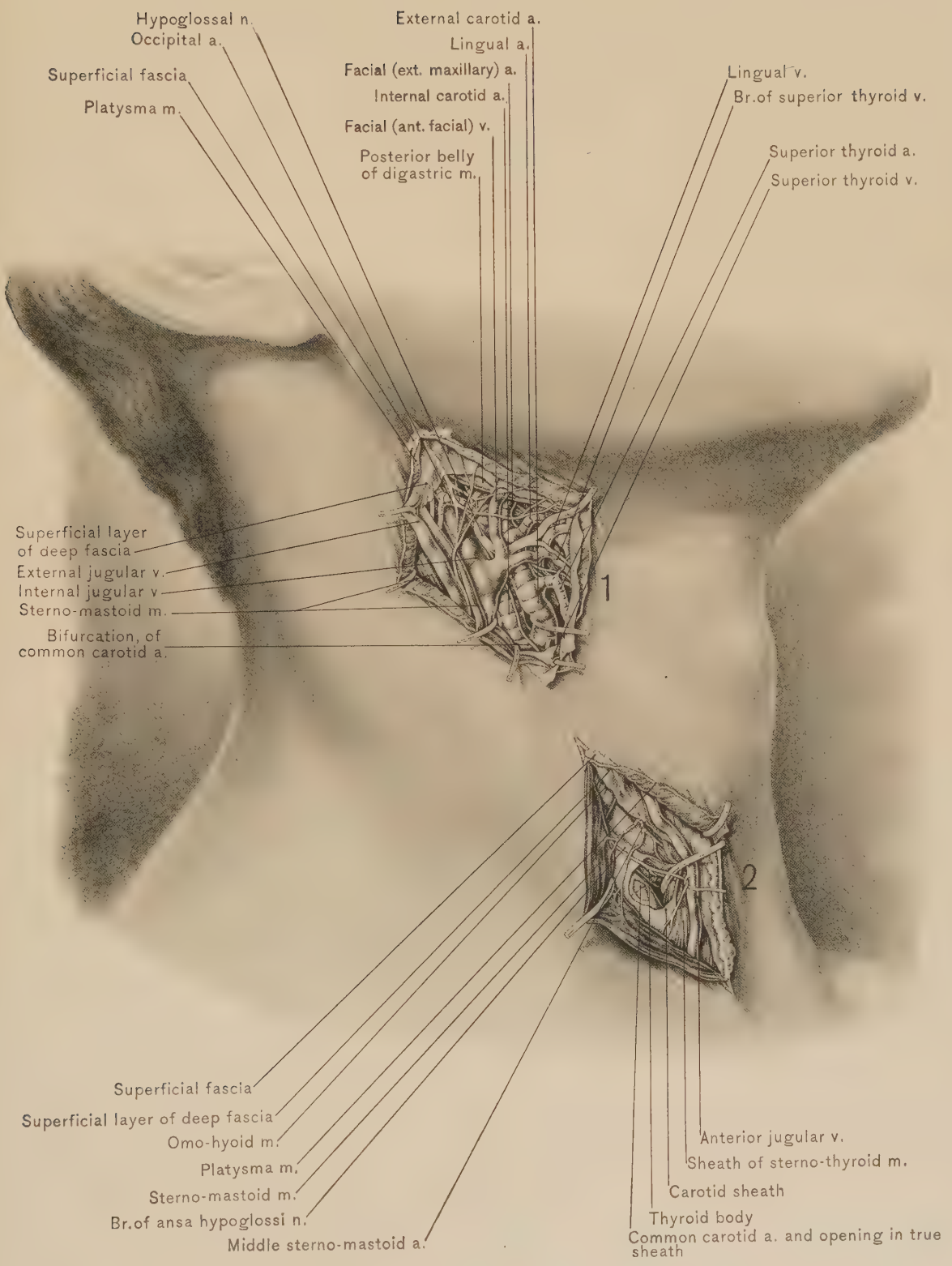
The *left common carotid artery* varies chiefly in its origin from the arch of the aorta. Its place of origin may extend into that of the innominate artery. When the right common carotid arises from the arch of the aorta, the two carotids may arise from a common trunk. The left common carotid occasionally arises from a left innominate artery.

Either common carotid artery may bifurcate higher or lower than the upper border of the thyroid cartilage. It may bifurcate above the level of the hyoid bone, giving off some of the branches which should arise from the external carotid artery. It may fail to bifurcate, the external carotid or internal carotid artery being absent. The point of bifurcation may be as low as the root of the neck. The common carotid may be absent, the external and internal carotid arteries then arising from the innominate artery or the arch of the aorta.

The common carotid artery may give origin to the thyroidea ima, the vertebral, the inferior thyroid, or some of the branches of the external carotid artery. The vagus nerve may lie in front of the common carotid artery.

The **external carotid artery** (Plates CCLXXII; CCLXXIII) is ligated after injury to this vessel or its branches, to check malignant growths, for cirsoid aneurysm of its branches, preliminary to removal of the parotid gland, and for various other conditions. The artery is usually tied between the points of origin of the lingual and superior thyroid arteries and in the superior carotid triangle, where it is more superficial, and the distance from the bifurcation of the common carotid artery is such as to favor the formation of a clot. Its course is represented by that portion of the line of the common carotid artery which is above the level of the superior border of the thyroid cartilage. In the superior carotid triangle, below the posterior belly of the digastric muscle, the external carotid artery is covered by skin and superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the anterior border of the sterno-mastoid

PLATE CCLXXIII.



(1) EXPOSURE OF EXTERNAL CAROTID AND INTERNAL CAROTID, AND OF THE SUPERIOR THYROID LINGUAL, FACIAL (EXT. MAXILLARY), AND OCCIPITAL AT THEIR ORIGIN; AND (2) EXPOSURE OF COMMON CAROTID IN INFERIOR CAROTID TRIANGLE.

muscle, and the sheath of the vessels; it is crossed by the hypoglossal nerve and the lingual and facial (*anterior facial*) veins. Higher in its course it is crossed by the stylo-hyoid and the posterior belly of the digastric muscle, and enters the parotid gland. To its medial side are the hyoid bone, the pharynx, the superior laryngeal and glosso-pharyngeal nerves, part of the parotid gland, and the ramus of the mandible. To its lateral side, at its origin, is the internal carotid artery. Behind it are the internal carotid artery, from which it is separated above, by the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve, the pharyngeal branch of the vagus nerve, the stylo-hyoid ligament, and part of the parotid gland. The superior larygneal nerve is also behind the artery.

The position of the patient should be the same as in ligation of the common carotid artery, the shoulders being elevated, the neck extended, and the face turned slightly to the opposite side. The incision should extend from the angle of the mandible downward along the anterior border of the sterno-mastoid muscle for about six centimeters (two and one-half inches), so that the greater cornu of the hyoid bone will be just above the center of the incision. The skin and superficial fascia, platysma muscle, some cutaneous vessels and nerves, and the superficial layer of the deep fascia are divided. The sterno-mastoid muscle is drawn lateralward, and the greater cornu of the hyoid bone, the hypo-glossal nerve, and the lingual and facial (*anterior facial*) veins located. The sheath is opened and the needle is passed from without medialward. The needle should be kept close to the artery in order to avoid the superior laryngeal nerve, which passes beneath the artery.

Collateral Circulation.—The collateral circulation, after ligation of the external carotid artery, is established by the anastomoses between the branches of this artery and the corresponding branches of the opposite external carotid artery.

Irregularities.—The external carotid artery may be absent, its branches arising from the common carotid, which continues upward as the internal carotid artery. It may be a short trunk, or it may arise at a higher or lower level than normal. Two or more of its branches, such as the superior thyroid, lingual, and facial (*external maxillary*) arteries, may arise from it by a common trunk. Some of its lower branches may arise from the common carotid artery. Occasionally it gives origin to additional branches, the superior laryngeal and middle sterno-mastoid branches of the superior thyroid artery, the ascending palatine and tonsillar branches of the facial (*external maxillary*) artery, the superior sterno-mastoid branch of the occipital artery, and the transverse facial branch of the superficial temporal artery.

The **superior thyroid artery** (Plates CCLXXI; CCLXXIII) is tied preparatory to removal of one-half of the thyroid gland, or to diminish the formation of inter-

nal secretions in toxic goiter. It arises from the external carotid artery just below the greater cornu of the hyoid bone, and runs forward and then downward and forward along the medial side of the carotid sheath. Its upper portion is superficial, while its lower portion is more deeply situated between the larynx and the carotid sheath. The superior laryngeal nerve lies beneath the upper portion of the artery, and its external laryngeal branch runs parallel with the lower part of the vessel. The artery may be tied near its origin and above its hyoid branch, but is preferably ligated between the origins of the superior laryngeal and the middle sterno-mastoid branches. In ligating it for toxic goiter it is best to ligate it near the superior thyroid pole, for then the cervical sympathetics to the gland are also ligated.

The patient is placed in the same position as for ligation of the external carotid artery, and an incision five centimeters (two inches) long made along the anterior border of the sterno-mastoid muscle. For good cosmetic results, the better incision is one made in a horizontal position so as to lie in one of the folds of the neck. The center of the incision should be on a level with the upper border of the thyroid cartilage. The skin and superficial fascia, the platysma muscle, and the superficial layer of the deep fascia are divided. The sterno-mastoid muscle is drawn lateralward, when the superior thyroid artery will be seen running downward along the medial side of the carotid sheath. The artery should be traced from its origin and tied above the origin of the middle sterno-mastoid artery, avoiding the superior thyroid vein, as well as the vein which connects the facial (*anterior facial*) or the submental vein with the anterior jugular vein and runs beneath the platysma muscle parallel with the anterior margin of the sterno-mastoid muscle. The needle is preferably passed away from the superior thyroid vein which usually runs on the lower side of the artery and which may form a plexus.

Irregularities of the superior thyroid artery and of the other branches of the external carotid artery are not of much surgical importance. The superior thyroid artery may be double, or it may be unusually small, the other thyroid arteries being larger than normal. It may arise from the common carotid artery or a trunk common to it and the lingual artery, or a trunk common to the superior thyroid, the lingual, and the facial (*external maxillary*) arteries. The hyoid, the superior laryngeal, and the middle sterno-mastoid branches may arise from the external carotid artery. The superior laryngeal artery may be unusually large, occasionally passing through a foramen in the thyroid cartilage, or it may pass along the thyroid cartilage and turn medialward under its lower margin. The crico-thyroid artery may be unusually large, and may send a branch downward over the crico-thyroid membrane to the isthmus of the thyroid body.

Such an abnormal branch would be divided in laryngotomy and perhaps in high tracheotomy. For this reason it is advisable thoroughly to expose the crico-thyroid membrane before incising it, as the entrance of blood into the larynx may cause broncho-pneumonia.

The **lingual artery** (Plates CCLXXI; CCLXXIII) is most frequently ligated preparatory to removal of the tongue. It is also tied to control hemorrhage from the artery or its branches in injuries, and especially in advanced carcinoma of the tongue. It *arises* from the external carotid artery, opposite the great cornu of the hyoid bone; its course (as described at p. 514) is divided into three portions:

The *first portion*, the most superficial part of the artery, extends from its origin to the lateral border of the hyoglossus muscle. It ascends to reach the upper border of the greater cornu of the hyoid bone, and the runs just above and parallel with that cornu. It is covered by the skin and superficial fascia, the platysma muscle, and the superficial layer of the deep fascia, and is crossed by the hypoglossal nerve, the lingual vein, and the digastric and stylo-hyoid muscles. This portion of the vessel rests upon the middle constrictor muscle of the pharynx and the superior laryngeal nerve. Its origin should be considered the point of election for ligation.

The *second portion* runs along the upper border of the hyoid bone beneath the hyo-glossus muscle, the lingual vein, the hypoglossal nerve, the digastric and stylo-hyoid muscles, the submaxillary (*submandibular*) gland, the superficial layer of the deep fascia, the platysma muscle, and the superficial fascia and skin. It rests here upon the middle constrictor muscles of the pharynx and the genio-glossus muscle. This portion is usually given as the point of election in ligation of the artery.

The *third portion* ascends between the hyo-glossus and genio-glossus muscles, pierces the latter muscle, and runs between it and the inferior lingual (*longitudinalis inferior*) muscle in the under surface of the tongue as far as its tip.

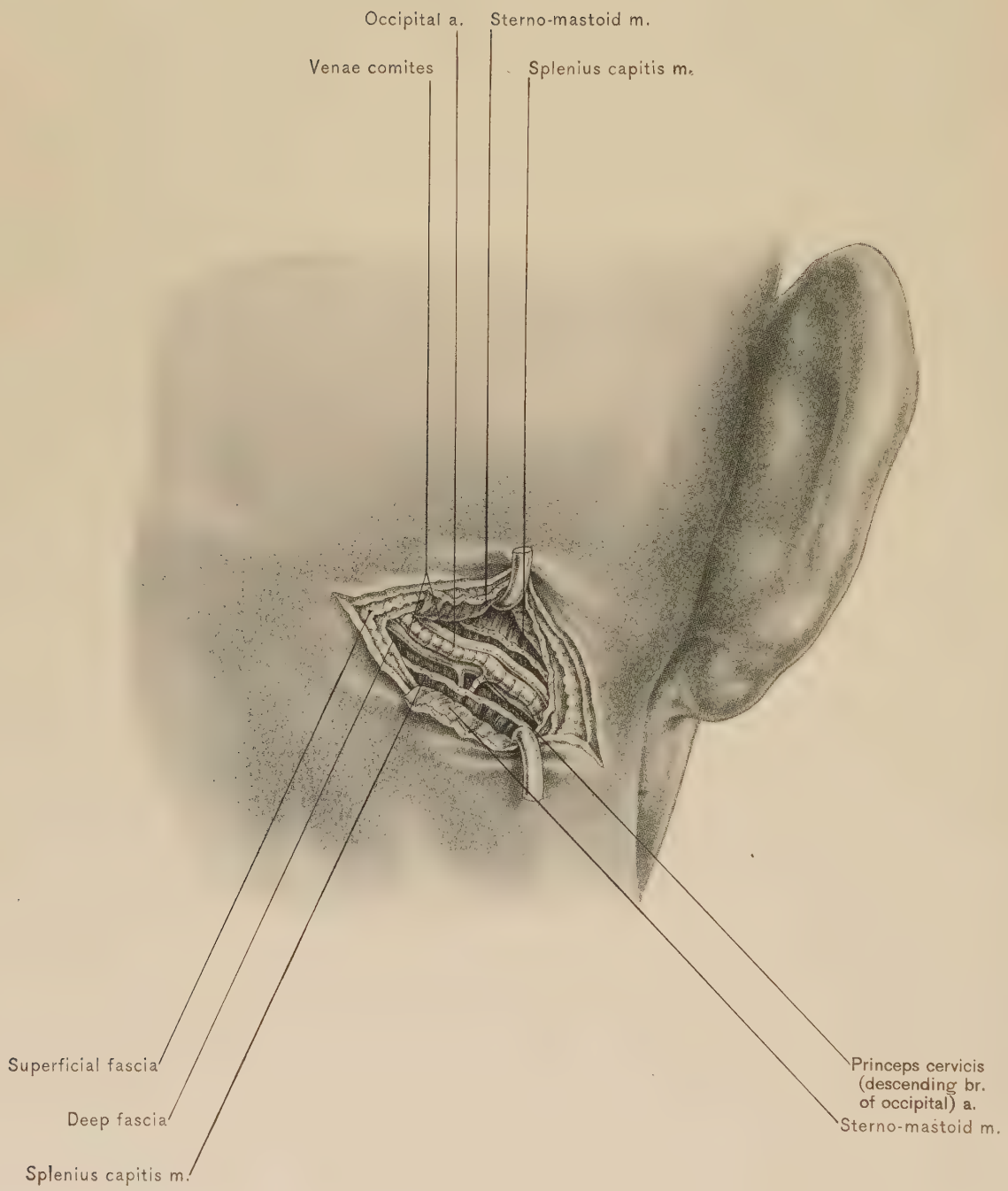
To ligate the lingual artery in its second portion, the patient should be placed in the same position as for ligation of the common and external carotid arteries. The mandible is drawn upward, and the incision made to extend from the anterior border of the sterno-mastoid muscle forward along the upper border of the greater cornu of the hyoid bone. The skin and superficial fascia, the platysma muscle, branches of the facial (*anterior facial*) and anterior jugular veins, and the superficial layer of the deep fascia are divided. The submaxillary (*submandibular*) gland is displaced and held well upward on the mandible, and the process of deep fascia beneath the gland divided. This exposes the tendon and bellies of the digastric muscle, the stylo-hyoid muscle, the hypoglossal nerve, the lingual vein (which is just below the nerve), the mylo-hyoid, and the hyo-glossus muscle.

The stylo-hyoid muscle and the tendon of the digastric muscle are drawn downward, the lingual vein and hypoglossal nerve upward, and an incision about one centimeter long should be carefully made through the hyo-glossus muscle just above the hyoid bone. If the incision through the hyo-glossus muscle is accurately made, the artery will project into the wound. The aneurysm needle is passed around the artery, and may include the venæ comites. Care should be taken not to injure the submaxillary (*submandibular*) gland, an accident which would probably give rise to a salivary fistula. To avoid the danger of opening the pharynx when incising the hyo-glossus muscle, care is required. Instead of dividing the hyo-glossus muscle, the artery may be ligated immediately before it passes under the lateral border of that muscle.

The *first portion* of the lingual artery is reached through an incision two and a half centimeters (one inch) long, carried from the sterno-mastoid muscle forward along the upper border of the greater cornu of the hyoid bone. The position of the patient should be the same as in the foregoing operation. The skin and superficial fascia, the platysma muscle, and the superficial layer of the deep fascia are divided. The submaxillary (*submandibular*) gland is displaced upward, and the process of deep fascia beneath the gland divided. The lingual vein and hypoglossal nerve are exposed and drawn upward, and the artery secured as it passes under the posterior margin of the hyo-glossus muscle. This operation is more difficult than ligating the second portion of the vessel, owing to the fact that the lingual vein, the hypoglossal nerve, the stylo-hyoid muscle, and the posterior belly of the digastric muscle lie in front of the artery. This portion of the artery may be secured at its origin through an incision five centimeters (two inches) long, made along the anterior border of the sterno-mastoid muscle. The center of the incision should be opposite the greater cornu of the hyoid bone. The location of the external carotid artery (as described under ligation of that vessel) is ascertained, and the origin of the lingual artery located opposite the greater cornu of the hyoid bone. The hypoglossal nerve and lingual and facial (*anterior facial*) veins must be avoided. This latter exposure is not difficult and has much to commend it. The facial (*external maxillary*) artery which has numerous anastomoses with the lingual may be simultaneously ligated.

Irregularities.—The most common irregularities of the lingual artery are the following: it may arise from a trunk common to it and the facial (*external maxillary*) artery, or from a trunk common to the superior thyroid, the lingual, and the facial (*external maxillary*) arteries; it may pierce the hyo-glossus muscle; occasionally it is given off as a branch of the facial (*external maxillary*); its sublingual branch may arise from the facial (*external maxillary*) artery, and the hyoid branch may be absent.

PLATE CCLXXIV.



EXPOSURE OF OCCIPITAL ARTERY FOR LIGATION.

The **facial (external maxillary) artery** (Plates CCLXXII; CCLXXIII) may be secured at its origin or as it passes over the border of the mandible at the antero-inferior angle of the masseter muscle. To ligate the facial (*external maxillary*) artery at its origin, which is just above that of the lingual artery, an incision should be made similar to that for ligation of the external carotid artery, except that the center of the incision should be just above the greater cornu of the hyoid bone. The facial (*anterior facial*) and the lingual veins, the anterior division of the temporo-maxillary (*posterior facial*) vein, and the hypoglossal nerve should be avoided. To tie the artery as it turns over the lower border of the mandible, an incision two and a half centimeters (one inch) long should be made below and parallel with this border of the mandible, so that the resulting scar will not be prominent. The skin and superficial fascia, the platysma muscle, and the superficial layer of the deep fascia are divided. As the facial (*anterior facial*) vein is behind the artery, the needle should be passed from behind forward.

Irregularity.—An irregularity of the facial (*external maxillary*) artery which is of importance is its possible termination as the submental artery, its area of distribution in the face being supplied by the nasal branch of the ophthalmic, the transverse facial, or the internal maxillary artery.

The **occipital artery** (Plate CCLXXIV) is ligated for cirsoid aneurysm or for injury. It may be tied at its origin, or as it passes through the occipital region. To tie it at its origin the shoulders should be elevated, the neck well extended, and an incision made along the upper part of the anterior border of the sterno-mastoid muscle. The origin of the artery will be found by tracing backward over the external carotid artery the hypoglossal nerve, which winds forward over that portion of the vessel. In the occipital region the artery may be secured through an incision carried obliquely backward and slightly upward from the tip of the mastoid process. The structures divided in the occipital region are the skin and superficial fascia, the superficial nerves and vessels, the superficial layer of the deep fascia, a portion of the sterno-mastoid muscle, the posterior process of the deep fascia (prevertebral fascia), and the splenius capitis muscle. The artery is readily identified in this region, at a point midway between the mastoid process and the external occipital protuberance.

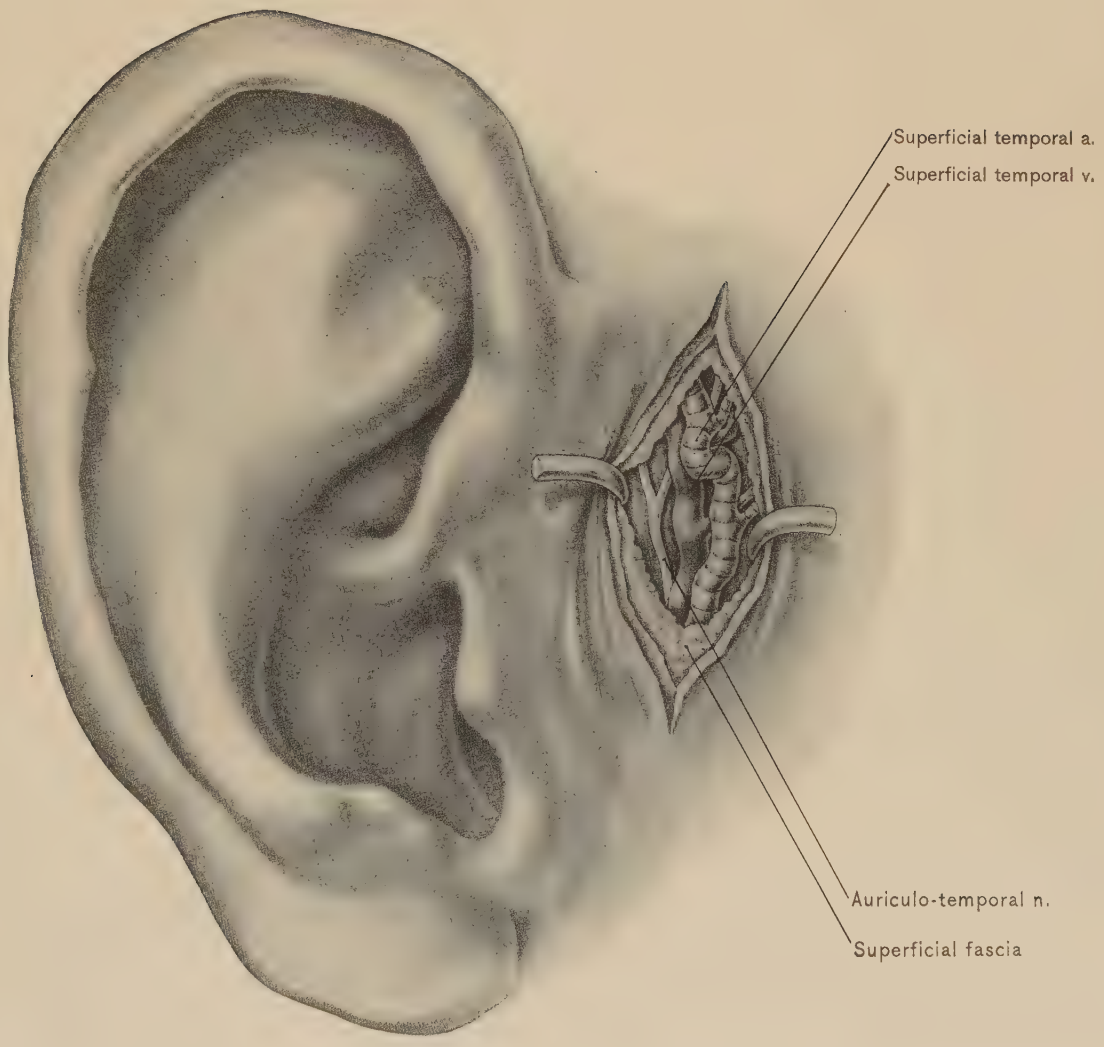
Irregularities.—The irregularities of the occipital artery which are of importance are the following: it may arise from the internal carotid artery or the ascending cervical branch of the inferior thyroid artery; it may cross over, instead of under the upper portion of the sterno-mastoid muscle; it may give origin to the posterior auricular or the ascending pharyngeal artery.

Irregularities of the ascending pharyngeal, the posterior auricular, the superficial temporal, and the internal maxillary arteries are not of much surgical importance.

The **superficial temporal artery** (Plate CCLXXV), like the occipital, is ligated in the treatment of injuries and for cirsoid aneurysm. The artery usually bifurcates into the anterior temporal (*frontal*) and posterior temporal (*parietal*) four to five centimeters (one and a half to two inches) above the zygoma, but it frequently divides at a lower level. It may be felt pulsating just in front of the auricle, where it crosses the posterior root of the zygoma; this is the point at which it should be tied. The incision should be vertical, about two and a half centimeters (one inch) in length, and be made over the vessel in front of the auricle. The structures divided are: skin, superficial and deep fasica. The superficial temporal vein lies posterior to the artery and overlaps it, and the auriculo-temporal nerve emerges from beneath the artery and vein, and then runs behind the vein. The temporal branches of the facial nerve cross the artery and vein in the parotid gland. The needle should be passed from behind forward.

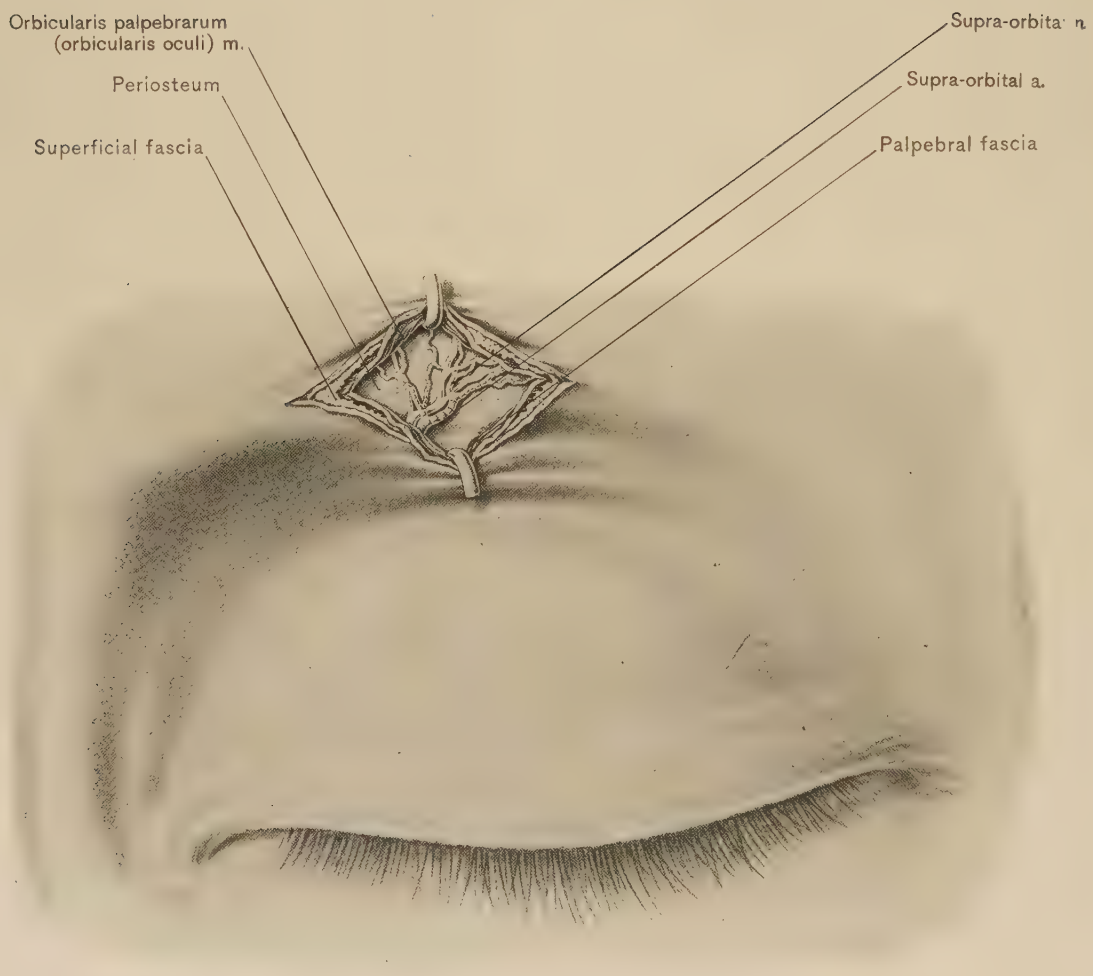
The **internal carotid artery** is rarely ligated. It may be tied after injury of the vessel and for traumatic aneurysm, the line for this vessel being the same as that for the common carotid artery. Its only accessible and superficial portion is at its origin, and is about two and a half centimeters (one inch) in length. The internal carotid artery begins at the bifurcation of the common carotid, opposite the upper border of the thyroid cartilage. At first it lies lateral to, and on the same plane as the external carotid artery, but it gradually passes beneath the latter vessel. In front of it in this location are: the skin and superficial fascia, the platysma muscle, the superficial layer of the deep fascia, the anterior border of the sterno-mastoid muscle, and the wall of the carotid sheath; behind it are the vagus nerve, the prevertebral fascia, superior sympathetic ganglion, and the rectus capitis anterior major (*longus capitis*) muscle; to the lateral side are the vagus nerve and the internal jugular vein; and to the medial side are the external carotid artery, the ascending pharyngeal artery, and the pharynx. The patient should be placed in the same position as for ligation of the common carotid artery. An incision eight centimeters (three inches) long is made over the anterior border of the sterno-mastoid muscle, the center of the incision being slightly above the level of the upper border of the thyroid cartilage. The skin and superficial fascia, the platysma muscle, and the superficial layer of the deep fascia are divided. The sterno-mastoid muscle is drawn lateralward, the posterior belly of the digastric muscle upward, the external carotid artery medialward, and the internal carotid artery lateralward. The anterior wall of the sheath of the artery should be carefully opened, and the needle passed from without medial-

PLATE CCLXXV.



EXPOSURE OF AURICULO-TEMPORAL NERVE AND SUPERFICIAL TEMPORAL ARTERY.

PLATE CCLXXVI.



EXPOSURE OF SUPRA-ORBITAL ARTERY AND NERVE.

ward, away from the internal jugular vein and the vagus nerve. In many cases the facial (*anterior facial*) and lingual veins cross the internal carotid artery to empty into the internal jugular vein.

Collateral Circulation.—The collateral circulation is established by the anastomosis of the vertebral arteries and the opposite internal carotid with the ligated artery through the circle of Willis (*circulus arteriosus*).

Irregularities.—The irregularities of the internal carotid artery which are of importance are the following: it may arise from the arch of the aorta or the innominate artery; its cervical portion may be tortuous; it may give origin to the occipital artery.

OPERATIONS UPON NERVES OF HEAD AND NECK

The **supra-orbital nerve** (Plate CCLXXVI) is exposed at the supra-orbital notch, or foramen, which is located at the junction of the intermediate with the medial third of the supra-orbital margin. The eyelid is drawn downward and the eyebrow held steady while a transverse incision is made along the supra-orbital margin. The incision, one to two centimeters (one-half to three-fourths of an inch) in length, divides the skin and superficial fascia and the orbicularis palpebrarum (*orbicularis oculi*) muscle. The nerve is now exposed, the supra-orbital vessels being on its lateral side. The palpebral fascia is divided, the orbital fat depressed, and the nerve traced into the orbit as far as possible, so that the frontal nerve may be reached and divided just before it bifurcates into the supra-orbital and supratrochlear nerves. About two and a half centimeters (one inch) of the supra-orbital nerve is resected. The supra-orbital vessels if injured, may be ligated through the same incision.

The **infra-orbital nerve** may be resected through an incision two centimeters (three-fourths of an inch) long, made at about eight to nine millimeters (one-fourth to three-eighths of an inch) below, and parallel with the infra-orbital margin, so that its center will lie over the infra-orbital foramen, which is situated in a line drawn from the supra-orbital notch to the second bicuspid tooth of the maxilla, and eight to nine millimeters (one-fourth to three-eighths of an inch) below the infra-orbital margin. The skin, superficial fascia, orbicularis palpebrarum (*orbicularis oculi*) muscle, and levator labii superioris (*infra-orbital head of quadratus labii superioris*) muscles are divided, the nerve is drawn out of the foramen, and as much as possible resected. This nerve may also be reached by an incision made through the mucous membrane of the mouth.

The **superior maxillary** (**maxillary**) **nerve** is resected in the spheno-maxillary (*pterygo-palatine*) fossa by way of the maxillary sinus, or antrum of Highmore, or through an incision at the side of the face.

The **Gasserian** or **semilunar ganglion** is removed through an osteoplastic resection of the temporal region. The ganglion is rarely resected today. The various nerve and ganglion resections for trigeminal neuralgia have been superseded by the Frazier-Spiller operation of resection of the sensory root of the ganglion. This operation gives complete and permanent relief and, since the incision for exposure is entirely within the hair line, gives excellent cosmetic results. The only serious complication likely to result is corneal ulceration. (This operation is described in Vol. I.)

The **inferior maxillary** (**mandibular**) **nerve** can be exposed at its exit from the foramen ovale. The reflected flap is made square, with its attached margin below. Two vertical incisions are made parallel with the margins of the ramus of the mandible, and extend from the level of the upper margin of the zygoma to half way down the ramus; the upper extremities of the incisions are connected by a transverse incision. The skin and superficial fascia are divided, the zygoma is sawed at each end, the temporal fascia and the masseteric fascia are divided, the zygoma and the masseter muscle are displaced downward, and the masseteric vessels and nerve are severed. Care is required to avoid injuring Stenson's (*the parotid*) duct and some of the large branches of the facial nerve which are at the attached margin of the flap. The coronoid process of the mandible is divided and reflected upward with the temporal muscle; and the upper head of the external pterygoid muscle is separated from the pterygoid ridge (*infratemporal crest*) of the sphenoidal bone and displaced downward. The nerve can then be exposed at the foramen ovale and divided with scissors. The small meningeal artery is necessarily divided with the nerve. The foramen ovale is situated about eight millimeters (one-fourth of an inch) in front of the spine of the sphenoidal bone, just behind the base of the lateral pterygoid plate, or lamina, and in a transverse line passing through the eminentia articularis (*articular tubercle*) of the temporal bone. This operation is hardly justifiable on account of the number of important tissues injured, the resulting paralysis of the muscles of mastication and of the mylo-hyoid muscle and anterior belly of the digastric muscle, the partial loss of power in moving the mandible, and the danger of infection and suppuration in so inaccessible a region as the pterygo-maxillary space (*infratemporal fossa*).

The **inferior dental** (**inferior alveolar**) **nerve** can be resected at the mental foramen, in the inferior dental (*mandibular*) canal, or before it enters that canal, but it is better to resect it before its entrance into the canal, in order that all the dental and gingival fibers of the nerve can be included. This portion of the nerve can be reached by an incision through the cheek or through the mucous membrane of the mouth. The external incision is preferable, not only because asepsis is impossible in wounds of the mouth, but because it is more easily performed, and

because it can be so located that the scar will not be prominent. The incision in the external method is angular and is made along the posterior border of the ramus to the angle of the mandible, and thence forward along the lower border of the mandible, each limb of the incision being about two and a half centimeters (one inch) in length. In the first stage of the operation, only the skin and superficial fascia are divided; next divide the masseteric fascia and the platysma muscle, being careful to avoid injuring the buccal and supramandibular (*mandibular*) branches of the facial nerve and the parotid gland. The lower limb of the incision should not extend far enough forward to divide the facial (*external maxillary*) artery or facial (*anterior facial*) vein. The lower portion of the masseter muscle is separated from the ramus of the mandible with the periosteal elevator and the knife, and is displaced upward. A small trephine is applied to the ramus midway between its anterior and posterior borders, and just above the level of the alveolar margin of the mandible. The trephine first divides the upper and thinner portion of the circle of bone; the remainder of the incision through the bone must be completed with the chisel and elevator, so that the inferior dental (*inferior alveolar*) vessels will not be injured. The inferior dental (*inferior alveolar*) vessels and nerve are seen lying upon the internal lateral (*pheno-mandibular*) ligament of the mandible. The nerve is separated from the vessels, drawn out with a blunt hook, and as much of it as possible resected.

In *internal neurectomy of the inferior dental* (*inferior alveolar*) *nerve*, through the mouth, the upper teeth are widely separated from the lower with a gag, and a vertical incision about two and a half centimeters (one inch) long is made through the mucous membrane along the medial margin of the anterior border of the ramus of the mandible. The anterior margin of the ramus is exposed, and the mucous membrane is separated from the ramus with a small periosteal elevator. The lingual nerve is located, the separation is extended a short distance further backward, and the spine of bone (*spine of Spix*) just below the inferior dental (*mandibular*) foramen is located with the finger. This spine gives attachment to the internal lateral (*spheno-mandibular*) ligament. This ligament, which covers the inferior dental (*inferior alveolar*) vessels and nerve which lie between it and the ramus of the mandible, is carefully divided, and the inferior dental (*inferior alveolar*) vessels and nerve are exposed at their entrance into the inferior dental (*mandibular*) canal. The nerve and vessels are gently drawn forward with a small blunt hook and traced upward for about twelve millimeters (one-half inch) above their point of entrance into the inferior dental (*mandibular*) canal, where, not being in close contact, they can be readily separated. The nerve is isolated from the vessels, and about one-half to one centimeter (one-fourth to one-half inch) removed, the upper end of the segment being divided first because this part

of the nerve retracts after being divided. If the nerve and vessels are traced too high, the internal maxillary artery is endangered. The wound in the mucous membrane is not closed.

The **lingual nerve** (Plate CCLXXVII) is divided or a portion of it excised for painful conditions, such as advanced cancer of the tongue. The nerve may be exposed by merely cutting through the mucous membrane of the floor of the mouth near the side of the tongue, and opposite the second molar tooth, or it may also be exposed by dividing the mucous membrane about twelve millimeters (one-half inch) below and behind the last molar tooth, where the nerve can readily be felt. More permanent results, however, will be obtained, in painful carcinomatous lesions of the face, by resorting to the Frazier-Spiller operation of resecting the sensory root of the Gasserian (*semilunar*) ganglion. The descriptions for exposure of the peripheral branches of the fifth, or trigeminal, nerve have been retained in this revision although the author is well aware they are now rarely used. Where the sensory root is not dissected, the method resorted to is that of alcoholic injection of the peripheral divisions.

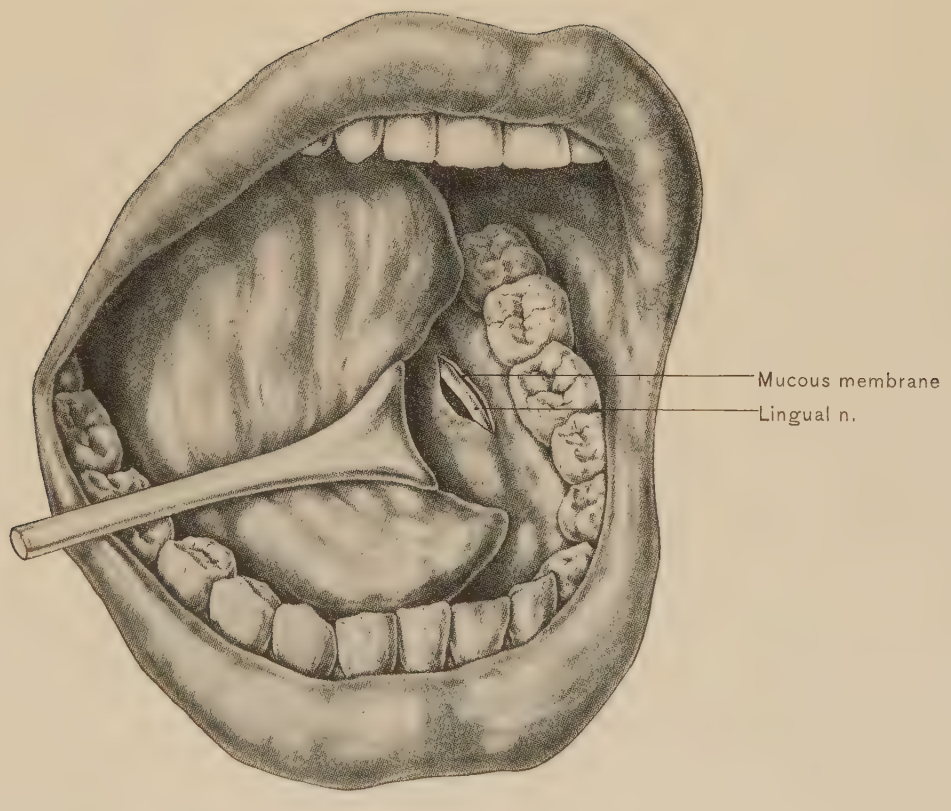
The methods for **alcholic injection** here described are taken from Patrick who has had a large experience in this work.

For the supra-orbital nerve a long hypodermic needle is used and the nerve is injected at the supra-orbital notch. Deep injections are not in order because of the close proximity of the optic, oculomotor, trochlear, and abducent nerves, as well as the large vascular channels. If the supra-orbital notch is not felt the pain experienced by firm pressure on the nerve may locate it. The reliable criterion of a successful injection is analgesia in the supra-orbital region.

For the superior maxillary (*maxillary*) and inferior maxillary (*mandibular*) divisions, a straight needle, twelve centimeters (one half inch) long, and one and three-fourths millimeters (one twelfth of an inch) thick is used. The needle is provided with a stylet and is graduated in centimeters. In the operation, the stylet is slightly withdrawn until the needle has penetrated the skin and subcutaneous tissue when it is pushed home, thus providing a blunt point for the deeper course.

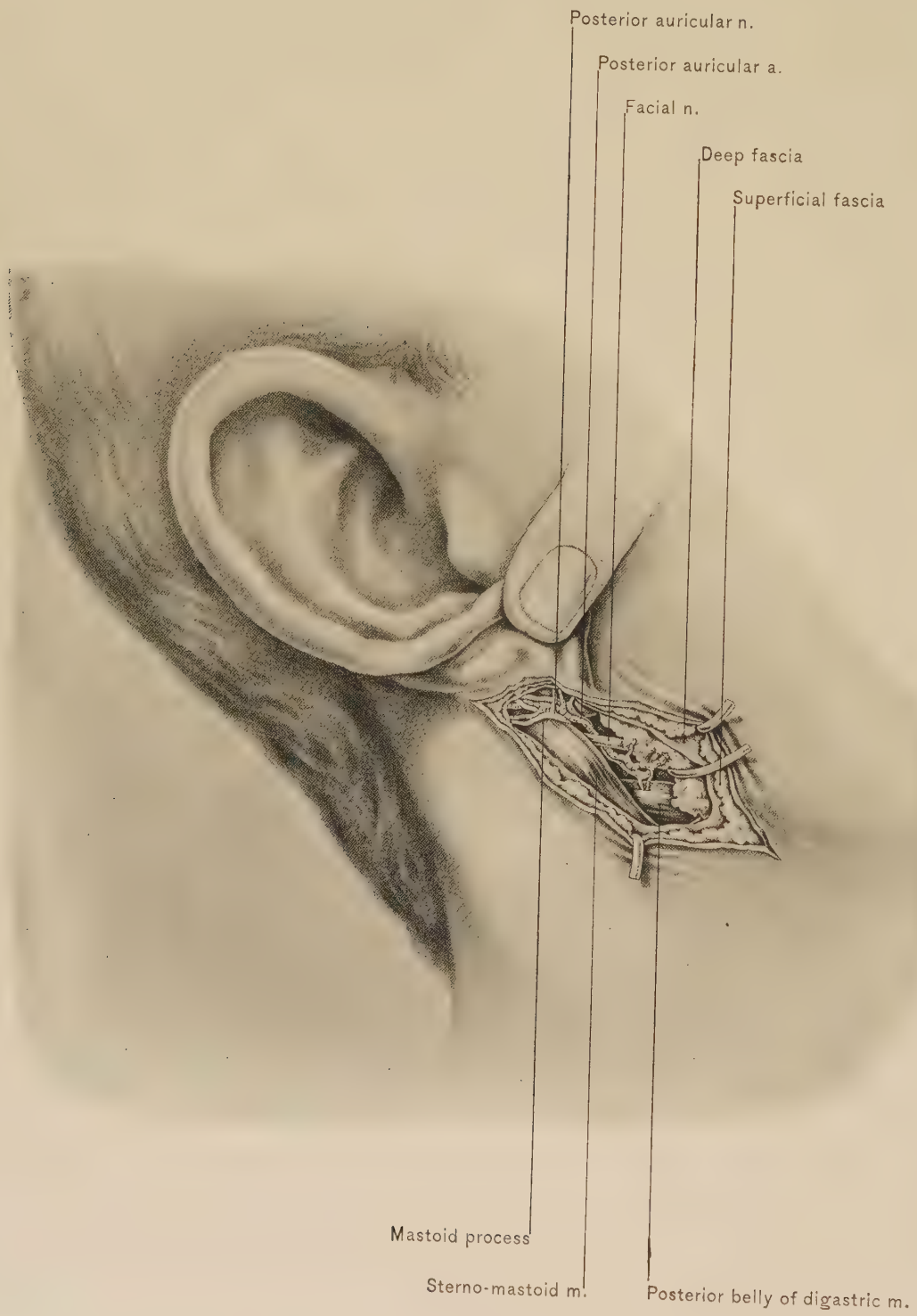
For the superior maxillary (**maxillary**) **nerve** a point of entrance is selected at the lower border of the zygoma a half a centimeter (one quarter of an inch) behind a perpendicular line let fall from the posterior edge of the orbital process of the malar (*zygomatic*) bone. The needle is directed straight in and inclined upward; that is, perpendicular to an anteroposterior line, so that the point, at a depth of five centimeters (two inches), will be on a level with the lower end of the nasal bones, or slightly lower than the posterior pole of the orbit. At this depth and angle, the point of the needle is supposed to engage the nerve as it emerges from the foramen rotundum into the spheno-maxillary (*pterygo-palatine*) fossa.

PLATE CCLXXVII.



EXPOSURE OF LINGUAL NERVE.

PLATE CCLXXVIII.



EXPOSURE OF FACIAL NERVE.

For the inferior maxillary (mandibular) nerve the point of entrance of the needle is at the lower border of the zygoma, two and a half centimeters (one inch) in front of the anterior root of the zygoma, a descending process which forms part of the anterior wall of the auditory canal and the posterior limit of the glenoid (*mandibular*) fossa. The needle is directed somewhat backward and slightly upward, and at four centimeters (one and seven-eighths inches) should reach the nerve. Offerhaus selects a point just in front of the preglenoid tubercle which constitutes the anterior limit of the glenoid (*mandibular*) fossa, and directs the needle at right angles to the anterioposterior plane. A valuable landmark is the lateral pterygoid plate. The foramen ovale is directly back of this and at about the same depth. It is well to strike this plate near its posterior edge and then work backward until the needle slips by it.

The **auriculo-temporal nerve** (Plate CCLXXV) is exposed where it first lies in relation with the superficial temporal vessels over the posterior root of the zygoma and in front of the auricle. The incision is the same as that made for ligation of the superficial temporal artery. The nerve is found just to the lateral side of the superficial temporal vessels.

The **facial nerve** (Plate CCLXXVIII) is secured near the stylo-mastoid foramen, as it lies superficial to the styloid process and above the posterior belly of the digastric muscle. In this location the trunk of the nerve is found before it gives off the stylo-hyoid and digastric branches, and before it bifurcates into its two divisions. The posterior auricular nerve arises from it close to the stylo-mastoid foramen. The incision begins behind the auricle, opposite the external auditory meatus, and is carried behind the lobule of the ear downward and forward to the angle of the mandible. A transverse incision may also be made behind the lobule. The skin and superficial fascia, the superficial layer of the deep fascia, and branches of the great auricular nerve are divided. The flaps which have been made are now dissected from the parotid gland, the sterno-mastoid muscle, and the mastoid process, the posterior auricular nerve, vein, and artery being avoided. The parotid gland is separated from the mastoid process, and the trunk of the nerve is found above the posterior belly of the digastric muscle, lying upon the styloid process. If the nerve has been cut near its entrance to, or in the parotid, repair is very difficult, since it may have divided into its terminal branches. The central end of the spinal accessory (*accessory*) or the hypoglossal is used in doing late anastomoses in cases where the central end of the facial nerve has been destroyed.

The **spinal accessory (accessory) nerve** is stretched, divided, or resected for spasmodic wry-neck. The nerve is secured at either the anterior or the posterior border of the sterno-mastoid muscle. When it is exposed behind the sterno-mastoid, it should be traced upward and divided above its sterno-mastoid

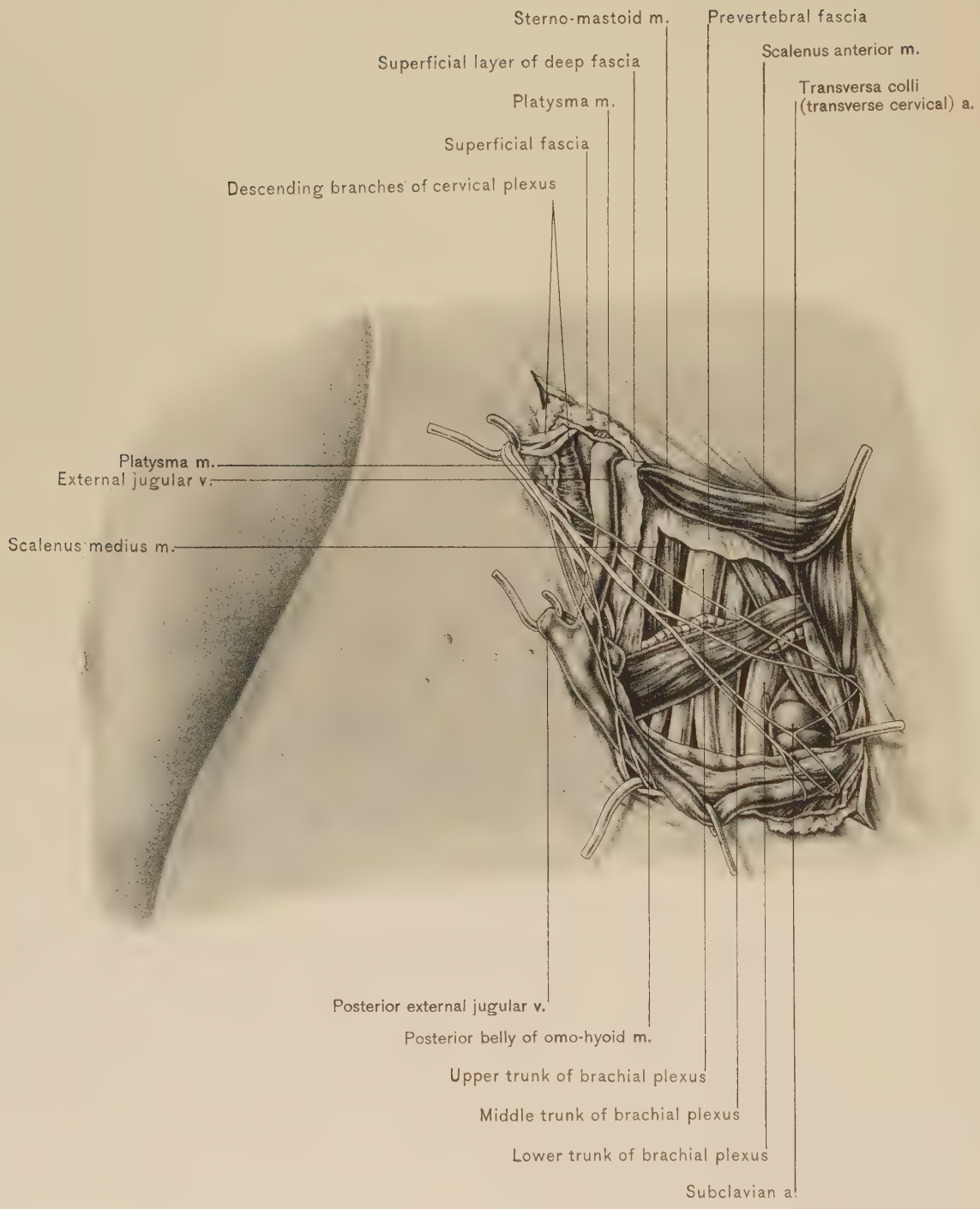
branches. In its course downward from the jugular foramen the nerve runs beneath the internal jugular vein, the occipital artery, and the posterior belly of the digastric muscle, and enters the under surface of the sterno-mastoid muscle about midway between its two borders and about five centimeters (two inches) from the tip of the mastoid process. It emerges from the muscle at about the middle of its posterior border. Between the posterior belly of the digastric muscle and the point where it enters the sterno-mastoid muscle, it is accompanied by the superior sterno-mastoid artery.

For exposing the nerve at the *anterior* border of the sterno-mastoid muscle, the patient is placed on his back, with the shoulders raised and the neck extended. The incision begins at the anterior border of the mastoid process, and is carried downward five to seven centimeters (two and a half to three inches) along the anterior margin of the sterno-mastoid muscle. The skin and superficial fascia, platysma muscle, a branch of the great auricular nerve, and the deep fascia are divided, the external jugular vein being avoided. The sterno-mastoid muscle is drawn lateralward, and the nerve, with its accompanying sterno-mastoid artery, can be felt just below the prominent transverse process of the atlas, lying upon the levator anguli scapulæ (*levator scapulæ*) muscle.

For exposing the spinal accessory (*accessory*) nerve at the *posterior* border of the sterno-mastoid muscle the shoulders are elevated, the face is turned to the opposite side, and the neck is flexed laterally toward the opposite shoulder. An incision about five centimeters (two inches) long is made along the posterior border of the sterno-mastoid muscle, with its center at the middle of that border of the muscle. The skin and superficial fascia, platysma muscle, and the superficial layer of the deep fascia are divided. The lesser occipital nerve is easily found as it runs along the upper half of the posterior border of the sterno-mastoid muscle. This nerve is traced downward to the spinal accessory nerve, with which it forms a loop. The spinal accessory (*accessory*) nerve is then traced beneath or through the deeper portion of the sterno-mastoid muscle and divided. This nerve in this region is occasionally severed in dissection of the lymph glands of the posterior triangle.

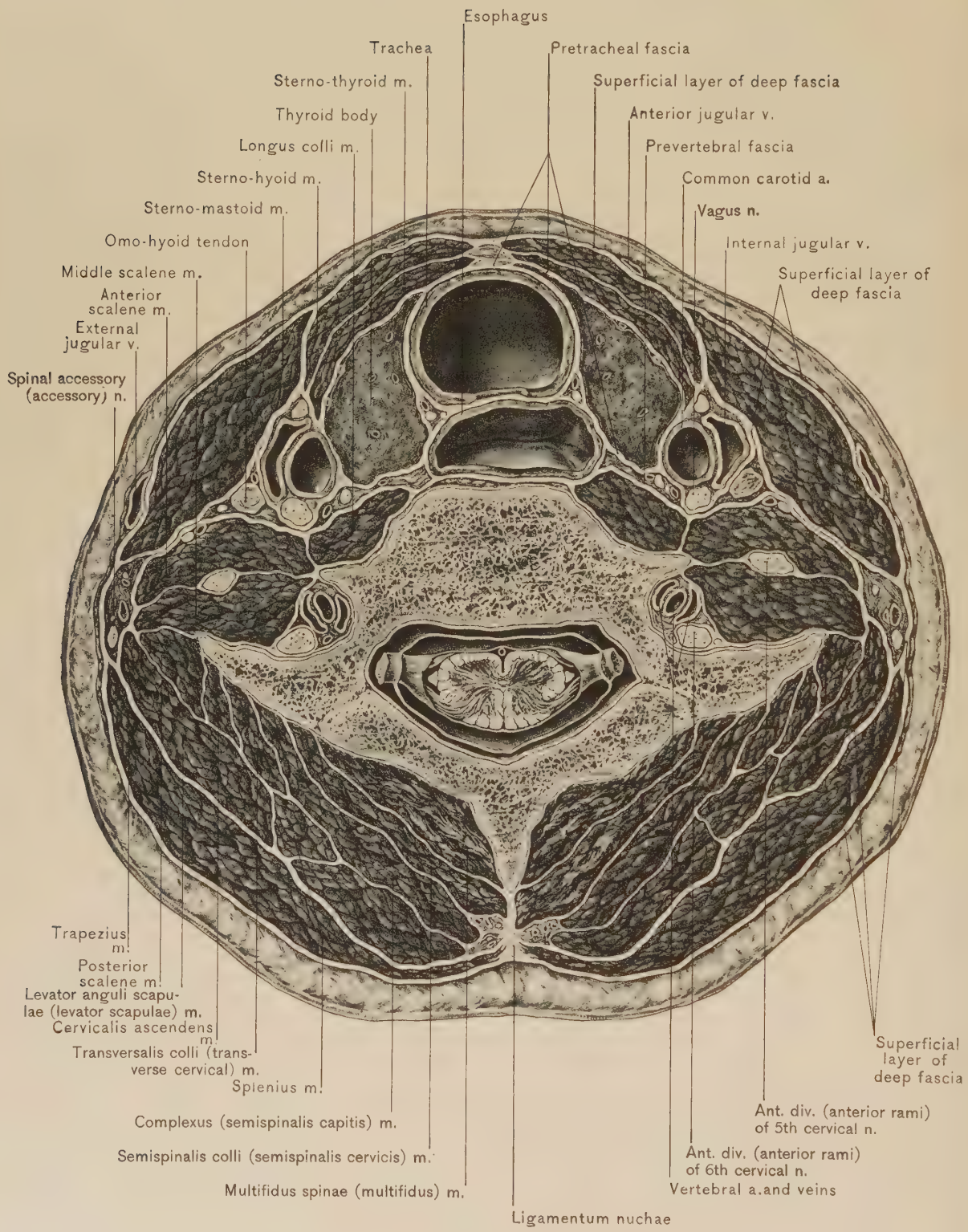
The **superficial branches of the cervical plexus** are exposed through the same incision as that made at the posterior border of the sterno-mastoid muscle for the spinal accessory (*accessory*) nerve. The *great auricular nerve* runs from the middle of the posterior border of the sterno-mastoid muscle toward the auricle. The *lesser occipital nerve* lies between the superficial layer of the deep fascia and its posterior process (prevertebral fascia), and just behind the upper half of the posterior margin of the sterno-mastoid muscle. The *superficial*, or *transverse, cervical* (*cutaneous colli*) *nerve* emerges from under the sterno-mastoid muscle at the middle of its posterior border, turns downward along that margin for a short

PLATE CCLXXIX.



EXPOSURE OF BRACHIAL PLEXUS OF NERVES.

PLATE CCLXXX.



SECTION OF NECK AT SIXTH CERVICAL VERTEBRA.

distance, and then runs transversely forward. The *descending superficial branches of the cervical plexus*, which divide into the suprasternal (*anterior supraclavicular*), supraclavicular (*middle supraclavicular*), and supra-acromial (*posterior supraclavicular*) nerves, are found running along the posterior border of the sterno-mastoid muscle just below the middle of that margin, and usually pass between the sterno-mastoid muscle and the external jugular vein.

The **brachial plexus** (Plate CCLXXIX) can be reached in the neck lateral to the scalenus anterior muscle. It emerges from between the scalenus anterior and scalenus medius muscles, and converges toward the apex of the axilla. The patient is placed on the back, with the shoulders elevated, the neck extended, and the face turned to the opposite side. The incision begins about one centimeter (one-half inch) above the middle of the clavicle. It is carried directly upward for about seven centimeters (three inches), and parallel with the posterior margin of the sterno-mastoid muscle. The skin and superficial fascia, and the platysma muscle are divided. The external jugular vein, which lies to the medial side of the incision, should be located; it may be necessary to divide the posterior external jugular or transverse cervical and suprascapular (*transverse scapular*) veins between ligatures. The superficial layer of the deep fascia is next divided. The posterior belly of the omo-hyoid muscle is drawn upward, the transverse cervical artery and the cords of the plexus and the position of the lateral border of the scalenus anterior muscle are located with the finger. The posterior process of the deep fascia (prevertebral fascia) is divided a short distance lateral to the scalenus anterior muscle, avoiding the nerve to the subclavius muscle, which runs along the lateral border of the scalenus anterior muscle, and the transverse cervical artery, which runs across the upper part of the plexus. The prevertebral fascia is reflected lateralward. The upper and middle cervical trunks of the plexus are found above the subclavian artery, the lower trunk being overlapped by the upper margin of that artery (Plate CLXXX).

THE LOWER EXTREMITY

SURFACE ANATOMY OF THE LOWER EXTREMITY

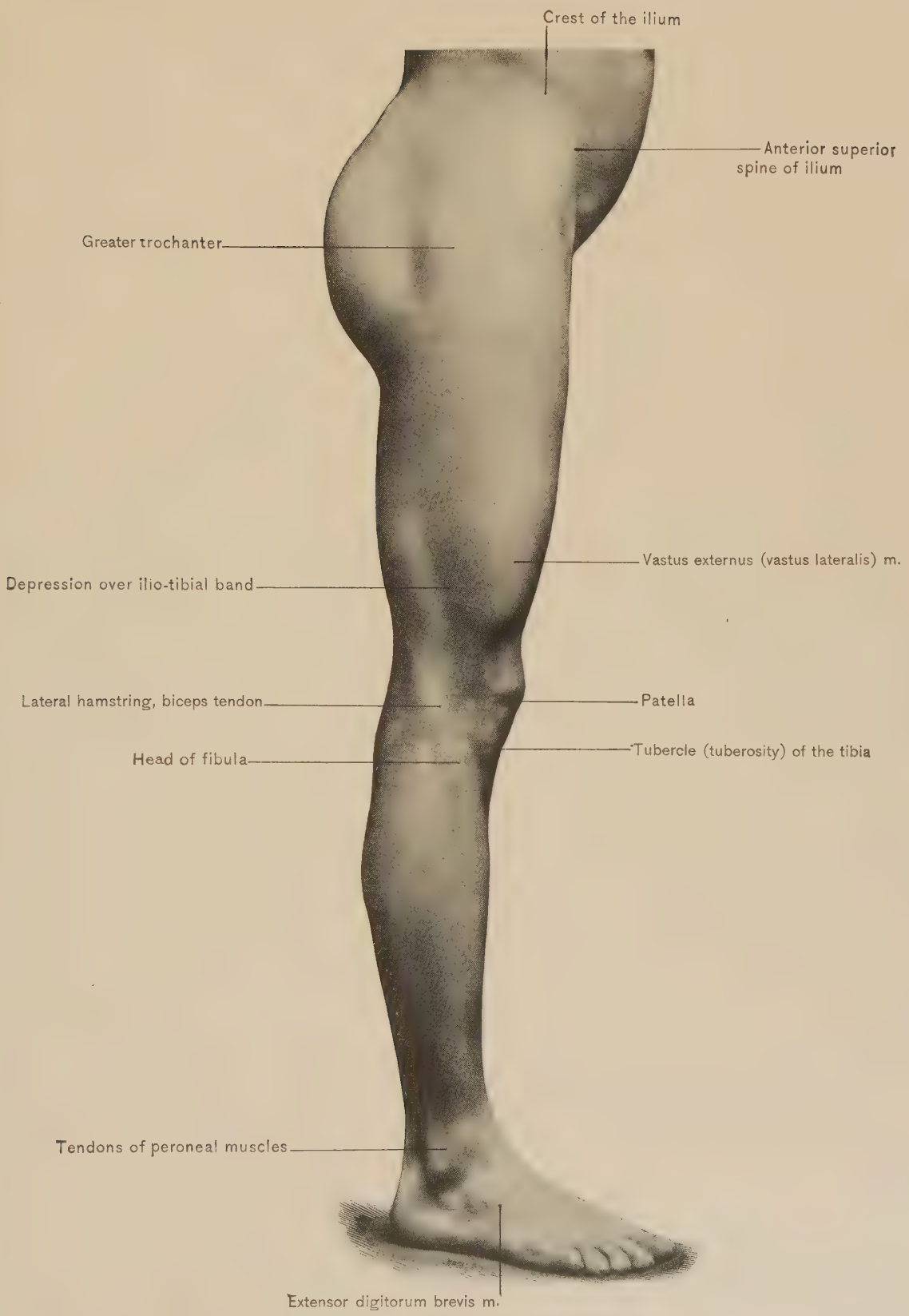
The **Thigh** is a truncated cone which extends from its beginning at the lower part of the trunk to the knee-joint. Its proximal limits are formed by Poupart's (*inguinal*) ligament in front; by the crest of the ilium, the sacrum, and the coccyx laterally and posteriorly, and by the rami of the ischium and pubis medially. **Poupart's (inguinal) ligament,** or **the crural arch,** can generally

be felt by making pressure in the inguinal furrow. The ligament is formed by the lower border of the aponeurosis of the external oblique, extending from the anterior superior spine of the ilium to the spine of the pubis (*pubic tubercle*), with a slight convexity downward. The spine of the pubis (*pubic tubercle*), even in fat subjects, can always be felt, and is a valuable guide in establishing anatomic landmarks in the differential diagnosis between a femoral and an inguinal hernia. Its position in relation to a hernia occurring in this region is important. An inguinal hernia makes its appearance above the ligament; a femoral hernia, below it. A chain of lymph glands is found parallel with Poupart's (*inguinal*) ligament, inflammation of which constitutes inguinal adenitis, or bubo. Such an enlargement is occasionally confused with an inflamed hernia.

Immediately below the furrow indicating the position of Poupart's (*inguinal*) ligament a second furrow appears when the thigh is slightly flexed upon the abdomen. It extends proximally and lateralward from the junction of the scrotum with the thigh and gradually disappears between the greater trochanter and the anterior superior spine of the ilium. It is a valuable landmark in amputation of the thigh by the transfixion method, as it crosses the front of the capsule of the hip-joint. The knife should be carried in the direction of this furrow, from without medialward. In hip-joint disease pressure over this furrow, to the medial side of the anterior superior spine of the ilium, elicits marked tenderness. The furrow is obliterated by distention of the joint from effusion. On deep pressure over this furrow at a point a little below the middle of Poupart's (*inguinal*) ligament, the head of the femur can be felt rotating when the limb is rotated on its long axis, and the pulsations of the common femoral artery are felt.

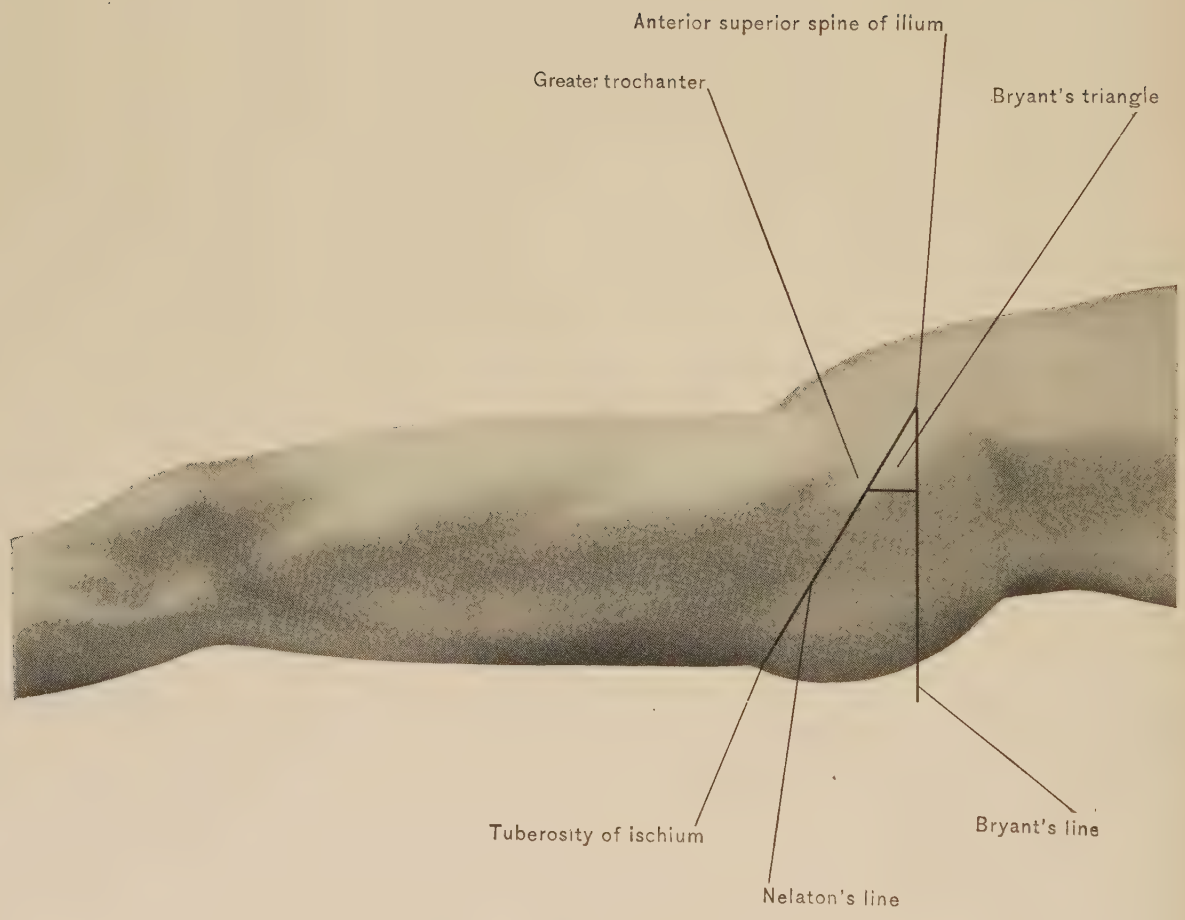
The **spine of the pubis** (**pubic tubercle**) and the **anterior superior spine of the ilium** (Plate CCLXXXI) are important landmarks. The measurements of the lower limb are usually taken from either of these spines to the tip of the medial malleolus, the iliac spine being the one generally used. Pressure upon the anterior superior iliac spines is of diagnostic value in suspected fracture of the pelvis. On the lateral side of the thigh, about ten centimeters (four inches) below and posterior to the anterior inferior spine of the ilium, below a depression, a well-marked prominence, **the greater trochanter,** can be very easily felt, especially if the limb is slightly rotated lateralward. The greater trochanter, with the exception of the fascial insertion of the gluteus maximus muscle and an intervening bursa, is subcutaneous. The top of this process is almost on a level with the pubic spine (*pubic tubercle*), and about twenty millimeters (three-fourths of an inch) lower than the top of the head of the femur. Its relation to the other bony prominences in this region is a most valuable aid in the diagnosis of injury or disease of the hip-joint and the neck of the femur. The following lines are

PLATE CCLXXXI.



SURFACE MARKINGS OF LATERAL ASPECT OF LOWER EXTREMITY.

PLATE CCLXXXII.



BRYANT'S AND NELATON'S LINES.

used in determining whether or not the greater trochanter holds its normal position: **Nélaton's line** (Plate CCLXXXII) passes from the anterior superior spine of the ilium to the most prominent part of the tuberosity of the ischium, and crosses the top of the greater trochanter at its middle when the lower limb lies in the axis of the body and midway between medial and lateral rotation. The non-alignment of these three bony points indicates displacement of the greater trochanter, as in dislocations and fractures. **Bryant's triangle:** the patient being flat on his back, (1) a line is dropped vertically to the bed from the anterior superior spine of the ilium; (2) from the top of the greater trochanter a straight line in the long axis of the thigh is drawn to meet the first; (3) to complete the triangle, a line is drawn from the anterior superior spine of the ilium to the top of the trochanter. This line is practically Nélaton's line. The second line will be found diminished on the damaged or diseased side, if the position of the greater trochanter has changed.

To the lateral side of the greater trochanter the **tensor fasciæ femoris,** or **tensor fasciæ latæ,** can be plainly seen. It extends seven and a half to ten centimeters (three to four inches) below the greater trochanter, beyond which point the strong ilio-tibial band can be felt. The **sartorius muscle** is found immediately medial to the latter. This muscle is one of the most serviceable landmarks of the thigh. It is made quite prominent by flexion of the hip and knee in combination with lateral rotation of the thigh. It forms the lateral boundary of Scarpa's (*femoral*) triangle, crosses the femoral vessels about ten centimeters (four inches) below Poupart's (*inguinal*) ligament, and runs over the roof of Hunter's (*adductor*) canal. Anteriorly in the middle line of the thigh is the prominence made by the **rectus femoris muscle,** to either side of which are found the **vasti muscles.** During voluntary extension of the knee-joint a depression can be felt between the vastus internus (*vastus medialis*) and the adductor muscles, which indicates the location of Hunter's (*adductor*) canal. With the knee flexed, the vastus internus (*vastus medialis*) muscle forms a prominence to the medial side of and proximal to the knee-joint.

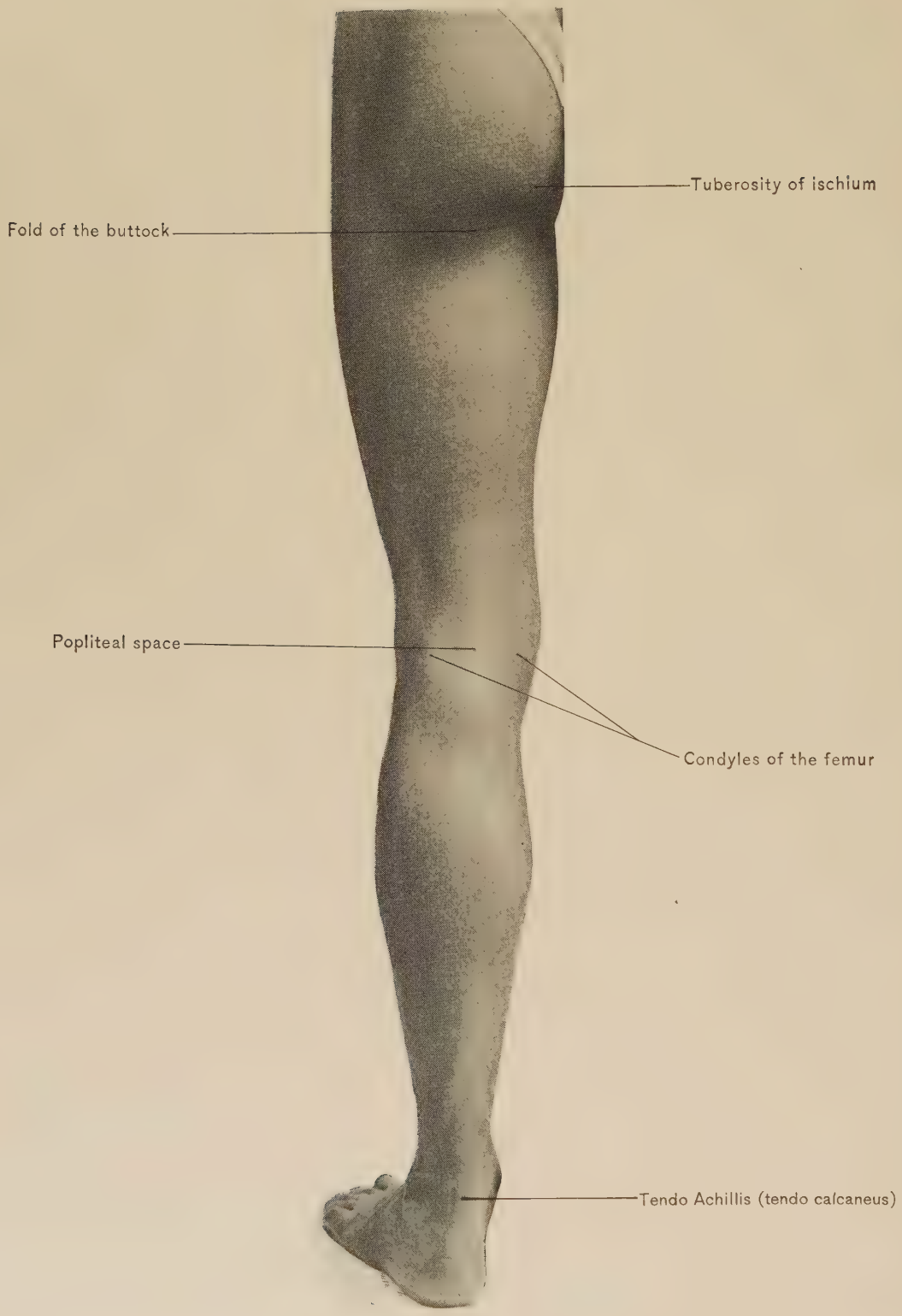
On the anterior aspect of the thigh and below Poupart's (*inguinal*) ligament is a slight depression which corresponds to **Scarpa's (femoral) triangle.** The boundaries of the triangle are formed by Poupart's (*inguinal*) ligament above, the sartorius muscle laterally, and the adductor longus medially. The latter muscle becomes prominent by abducting the thigh. Near the base of the triangle are two rows of lymph glands which can often be felt. The triangle is of importance mainly because its apex is the point of election for the ligation of the superficial femoral artery and because in its medial aspect a femoral hernia presents.

The **saphenous opening** (**fossa ovalis**) is about three and three-quarters centimeters (an inch and a half) lateral to the spine (*tubercle*) of the pubis, and just below the medial third of Poupart's (*inguinal*) ligament. It is usually marked by a slight depression in the skin, at which point a femoral hernia first appears. The long (*great*) saphenous vein passes through it to empty into the common femoral vein. On either side of the opening there are lymph glands which may become enlarged and may be confounded with a hernia.

The **femoral ring** is under the medial end of Poupart's (*inguinal*) ligament; it lies deeper than the saphenous opening (*fossa ovalis*), and about twelve millimeters (half an inch) above it. Its plane faces downward, and is thus at right angles to the plane of the saphenous opening (*fossa ovalis*) which faces forward. It is bounded anteriorly by Poupart's (*inguinal*) ligament, posteriorly, by the ramus of the pubis and the fascia covering it, medially, by Gimbernat's (*lacunar*) ligament, and laterally by the femoral vein and the fascia covering it. A femoral hernia passes downward through the femoral ring, forward through the saphenous opening (*fossa ovalis*), skirting the lower margin of the superior falciform process, or Hey's ligament, and then upward over Poupart's (*inguinal*) ligament. In reducing a femoral hernia it is therefore necessary first to draw it downward to the saphenous opening (*fossa ovalis*), then to push it backward beyond the lower edge of the superior falciform process, and upward through the femoral ring into the abdominal cavity. Holden's rule for finding the femoral ring is to locate the femoral artery by its pulsation as it crosses the horizontal ramus of the pubis; then allow twelve millimeters (one-half inch) on its medial side for the femoral vein, beyond which is the femoral ring. The course of the **common** and the **superficial femoral arteries** is indicated by the proximal two-thirds of a line drawn from a point mid-way between the anterior superior spine of the ilium and the spine (*tubercle*) of the pubis to the adductor tubercle. The point of election for the ligation of the superficial femoral artery is at the apex of Scarpa's (*femoral*) triangle. This point is chosen because it is readily determined by using the sartorius as a guide, because the vein lies behind the artery at this point, and because of its distance from the origin of the profunda femoris. In Hunter's (*adductor*) canal the artery and vein are closely adherent, and ligation is more likely to cause injury to the vein. Compression of the common femoral artery is best accomplished by pressure downward and a little backward (the patient being on his back) at a point about midway between the anterior superior spine of the ilium and the spine (*tubercle*) of the pubis. The artery is easily recognized by its strong pulsations.

The Buttocks.—The distinct **bony landmarks of the buttocks** are: (1) the posterior superior iliac spines, which are on the same level as the second sacral

PLATE CCLXXXIII.



SURFACE MARKINGS OF POSTERIOR ASPECT OF LOWER EXTREMITY.

spine and the middle of the sacro-iliac joint; (2) the sacral spines, of which the third marks the lowest level of the spinal meninges and the inclosed fluid; (3) the two tubercles of the last sacral vertebra, which are landmarks for the introduction of the needle for sacral anesthesia; (4) the base of the coccyx, from which a cutaneous furrow runs to the anus, and sometimes forms a dimple, and (5) the tuberosities of the ischia, on each side of the anus, which mark the lateral boundaries of the perineum. The tuberosities of the ischia are covered by muscle and fat in the erect attitude, but only by fat and a bursa in the sitting posture. The buttock is composed of the gluteal muscles liberally covered by fat. Inequality in the size of the buttocks may indicate hip-joint disease.

The **fold of the buttock** (Plate CCLXXXIII) is the crease formed by the skin, fat, and fascia overhanging the back of the thigh; it is supposed to mark the lower edge of the gluteus maximus muscle, but this is incorrect, since the furrow crosses the lateral portion of that muscle, and at its medial end is below the origin of the muscle. Pressure can be made in this fold, between the tuberosity of the ischium and the greater trochanter, but nearer the former, on the great sciatic (*sciatic*) nerve. This is shown by the succeeding numbness of the area of distribution of the nerve if the pressure is continued. Continuous tension due to extreme flexion of the hip causes benumbing of the nerve. Pressure upon the nerve at the back of the thigh while in the sitting posture also often produces numbness. This fold becomes less prominent in hip-joint disease.

The **superior gluteal artery** emerges from the pelvis at a point opposite the union of the medial with the middle third of a line extending from the posterior superior spine of the ilium to the top of the greater trochanter when the thigh is rotated medialward. The sciatic artery emerges about twelve millimeters (one-half inch) below the superior gluteal.

The **internal pudendal artery,** as it crosses the spine of the ischium in its passage from the greater to the lesser sacro-sciatic (*sciatic*) foramina, is indicated by the junction of the middle and distal thirds of a line drawn from the posterior superior spine of the ilium to the tuberosity of the ischium. It can be felt pulsating at that point in thin subjects and can be compressed there in hemorrhage from this vessel. The **sciatic (inferior gluteal) artery** is close to it, but on its lateral side.

Sitting upon a hard surface puts the weight of the superimposed body upon the tuberosities of the ischium, while a soft seat and cushions bear upon the soft parts also, and impede the circulation through the extrapelvic vessels, thus tending to produce intrapelvic congestion. It is likely that this factor is often overestimated.

The Knee.—The **bony points** about the knee are the patella, the condyles of the femur, the tubercle (*tuberosity*) of the tibia, the tuberosities (*condyles*) of the tibia, the head of the fibula, and the adductor tubercle.

The patella (Plate CCLXXXIV).—With the extensor muscles relaxed, the patella can be readily moved from side to side, and its borders distinctly felt. The medial border is a little more prominent than the lateral. Numerous sulci may be felt on the anterior surface of the bone, into which tendinous bundles from the tendon of the rectus femoris muscle are inserted. MacEwen has pointed out that these fibers are liable to fall between the ends of the fractured patella and thus prevent bony union. Although the patella articulates with the femur, it has no definite fixed relation to that bone. In extension of the leg the patella rides upward in front of the condyles of the femur, and in extreme extension only the distal part of the patella is in contact with the bone, the proximal portion lying on the bed of fat which covers the distal part of the femur. In this position the distal end of the patella is just above the level of the line of the knee-joint. In flexion of the leg, the relative position of the patella changes with the degree of flexion. Thus, in semiflexion the middle third of the patella rests upon the most prominent part of the condyles. This position is considered the one in which the patella is most liable to be fractured by muscular force, as the strain of the quadriceps extensor femoris (*quadriceps femoris*) muscle is at right angles to the long axis of the bone. In extreme flexion the bone recedes into the groove between the condyles. In this position only the proximal third rests upon the femur, the remainder lying on the cushion of fat between it and the tibia.

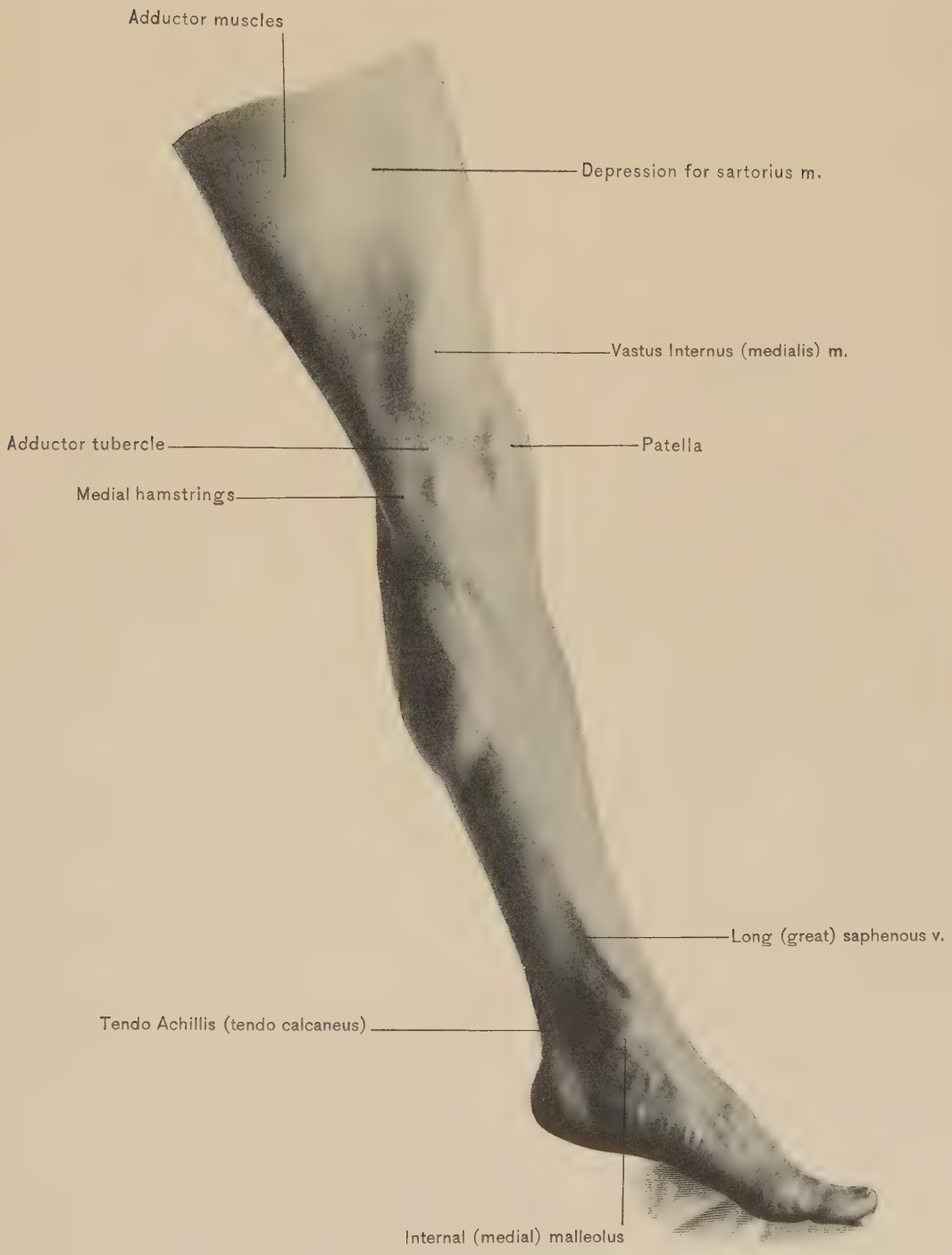
With the leg extended, the condyles of the femur can readily be felt on either side of the patella. The medial one is generally the more prominent. The tubercle (*tuberosity*) of the tibia is felt in front of the proximal extremity of the tibia, in line with the tendon of the patella which in reality is the continuation of the tendon of the quadriceps extensor (*quadriceps femoris*) muscle, the patella being a sesamoid bone.

The **head of the fibula** rests upon the posterolateral part of the tibia at about the level of the tubercle (*tuberosity*) of the tibia. The anterior tibial (*deep peroneal*) nerve crosses the fibula just distal to its head to enter the anterior surface of the leg, and is sometimes compressed in thin persons when the legs are crossed, causing numbness and tingling along its course.

The **adductor tubercle,** upon the base of the medial condyle, gives attachment to the tendon of the adductor magnus, and marks the position of the epiphyseal line of the distal end of the femur, and the most proximal part of the trochlea for the patella—points useful to remember in knee-joint excision. At about twelve millimeters (one-half inch) proximal to this point the femur is divided in the operation of osteotomy for the correction of knock-knee.

The tuberosities (*condyles*) of the tibia are a lateral and a medial.

PLATE CCLXXXIV.



SURFACE MARKINGS OF MEDIAL ASPECT OF LOWER EXTREMITY.

The **lateral tuberosity** (**lateral condyle**), upon the lateral side of the head of the bone, has attached to it the distal end of the lateral band of the fascia lata (ilio-tibial band), some times described as a tibial insertion of the tensor fasciæ femoris (*tensor fasciæ latæ*). It also indicates the most distal level of the synovial sac of the knee. The **medial tuberosity** (**medial condyle**) is not so prominent as the lateral. Between the medial tuberosity (*medial condyle*) and the medial condyle of the femur is a depression in which a dislocated medial semilunar fibrocartilage can be felt.

The **tendo patellæ,** the large tendon of the quadriceps, is in relation posteriorly, in its proximal half, with the synovial sac of the knee-joint, and in its distal half with a pad of fat. It is vertical in position and should be in line with the tibial tubercle (*tuberosity*) and the middle of the ankle in a well-formed leg, a point to be remembered in setting fractures, especially if they are multiple or comminuted.

The **synovial membrane** of the knee projects proximally fully five centimeters (two inches) above the patella when the knee is extended; laterally, it extends further upward under the vastus internus (*vastus medialis*) than it does under the vastus externus (*vastus lateralis*). In bending the knee the tubercle (*tuberosity*) of the tibia is carried away from the front of the condyles of the femur, drawing with it the tendo patellæ and the patella, which in turn draws the proximal pouch of the synovial sac downward, so that this does not extend so high up on the femur when the knee is flexed as when the joint is extended. It is for this reason that the knee is flexed in operations upon the distal end of the femur. The distal limit of the synovial sac of the knee-joint is at the top of the tibia.

The **popliteal** (diamond-shaped) **space,** or **fossa,** is seen as a depression behind the knee. It is bounded superolaterally by the lateral hamstring tendon, the biceps femoris; superomedially by the medial hamstring tendons, which are, from medial to lateral, the semitendinosus, the semimembranosus, and the gracilis. The sartorius skirts the posteromedial part of the knee, giving it a graceful swell. The inferior boundaries, the two heads of the gastrocnemius, are not distinctly perceptible on the surface. With the knee extended, the contents of the popliteal space form a longitudinal ridge in the median line.

The **popliteal artery** lies deep in the mid-line of the popliteal space upon the back of the distal end of the femur, the posterior (*oblique popliteal*) ligament of the knee-joint, and the popliteus muscle. The guide to it is the lateral margin of the semimembranosus. It is overlaid by the internal popliteal (*tibial*) nerve and the popliteal vein, the nerve being the more superficial.

The **peroneal** (**common peroneal**) **nerve** can be felt in thin people on the medial side of the tendon of the biceps femoris. Care should be exercised not to cut it in tenotomy of the biceps femoris.

The Leg and Ankle (Plate CCLXXXV).—Besides the tubercle (*tuberosity*) of the tibia, the leg is marked anteriorly by the sharp edge of the tibia, or **shin,** by a smooth subcutaneous surface of the same, and to a certain extent by its medial edge, which is not so well defined. The distal third of the tibia is the narrowest part and most subject to fracture.

The **fibula** is almost buried by the peroneal muscles, and is subcutaneous in its distal fourth only, where fractures occur frequently. It lies on a plane posterior to that of the tibia, a point to be remembered in amputation by the flap method. It is arched posteriorly.

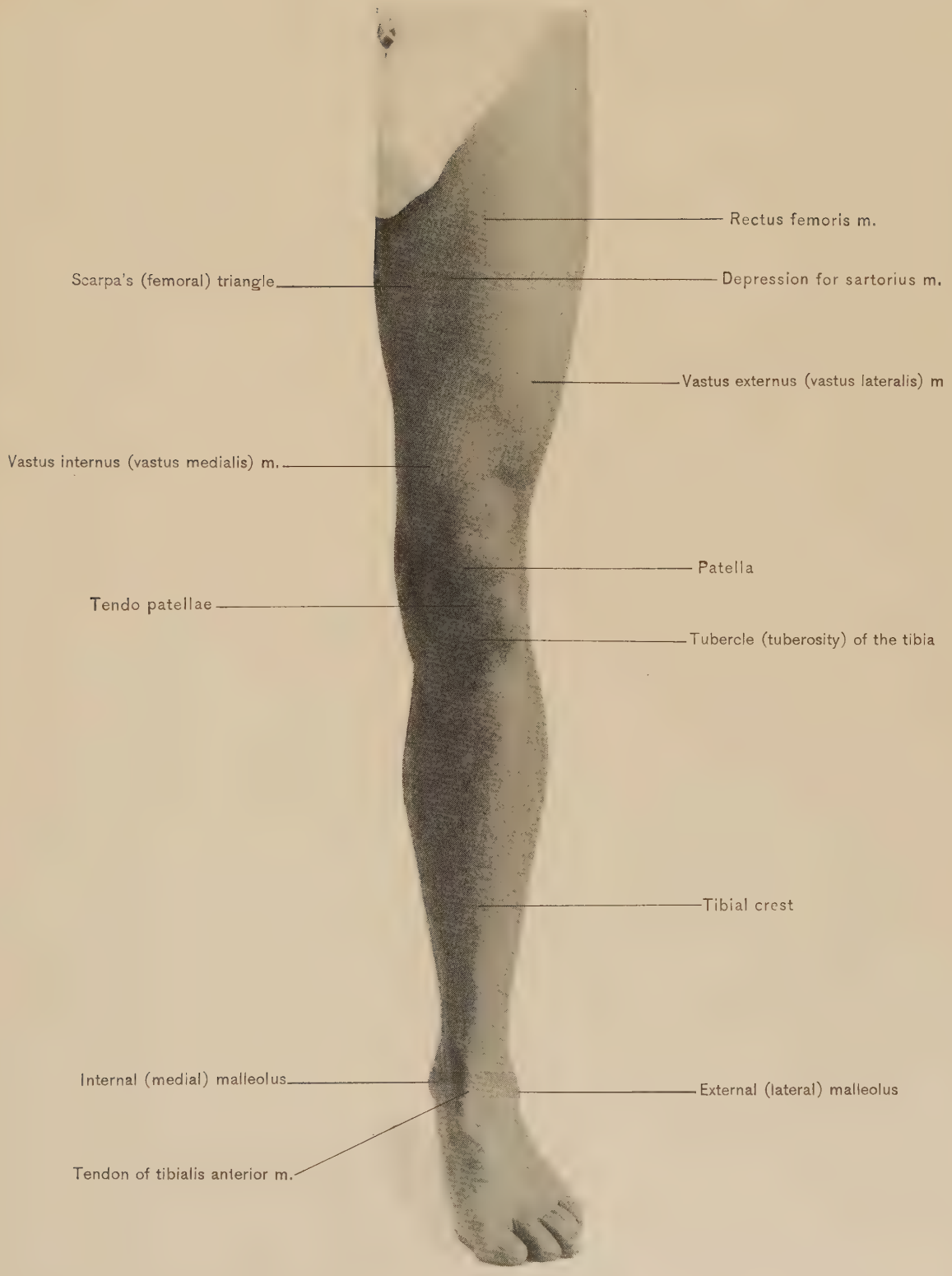
Upon the anterior surface of the proximal two-thirds of the leg, when the ankle is voluntarily and strongly flexed, a firm elevation appears between the two bones, due to the contraction of the anterior tibial and the extensor muscles of the toes. This is a point of soreness in athletes when beginning training for a walking match, because of the strain upon the muscles in keeping the toes off the ground in the descent of the foot at each long stride.

The **malleoli** (Plate CCLXXXV) are the important landmarks of the ankle, the lateral malleolus descending lower than the medial malleolus. The medial one is the wider and extends further forward than the lateral, but is on the same plane with it posteriorly. Holden appropriately likens the shape of the lateral malleolus to a serpent's head. In a well-formed leg the medial malleolus is in a line with the medial border of the patella and the medial side of the head of the metatarsal bone of the great toe. This rule is useful when setting fractures by which these relations are disturbed. The circumference of the ankle at the malleoli is important in all injuries in determining whether or not a separation of the distal tibio-fibular articulation has occurred. It is also important to measure the distance from between the malleoli to the great toe, after reducing posterior luxation of the astragalus (*talus*) in a Dupuytren's fracture.

Behind the ankle is the prominent **tendo Achillis** (**tendo calcaneus**), which is narrowest at about the level of the medial malleolus, where it is preferably cut in tenotomy. It bends slightly forward and is held in that position by a thickened portion of the deep fascia attached to the tibia and fibula. This portion of the deep fascia may be considered a posterior annular ligament. On either side of the tendon, between it and the malleoli, are two distinct depressions.

The **tendon of the tibialis posterior** lies close to the back of the tibia, upon the medial side of the ankle. It is invested by a synovial sheath from its insertion into the tubercle of the scaphoid (*navicular*) to three and three-quarters centimeters (an inch and a half) proximal to the apex of the medial malleolus. In tenotomy it should, therefore, be cut about five centimeters (two inches) proximal to the apex of the malleolus, so as to avoid the sheath. The guide to this tendon is

PLATE CCLXXXV.



SURFACE MARKINGS OF ANTERIOR ASPECT OF LOWER EXTREMITY.

the medial edge of the tibia. In a fat leg this will not answer, and it is then advisable to cut exactly midway between the front and back of the leg, a little anterior to this point being the long (*great*) saphenous vein and a little posterior to it is the posterior tibial artery.

The **peroneal tendons** pass behind the lateral malleolus, and in tenotomy should be severed about five centimeters (two inches) above the tip of the malleolus so as to avoid their synovial sheaths.

The **tendon of the tibialis anterior** (in tenotomy) should be cut about two and a half centimeters (one inch) above its insertion into the internal (*first*) cuneiform bone, to avoid the lower end of its synovial sheath, the knife being inserted on its lateral side to avoid the dorsalis pedis artery.

The other tendons upon the front of the ankle are those of the extensor hallucis proprius (*extensor hallucis longus*) and extensor digitorum longus, being lateral to the tendon of the tibialis anterior in the order named.

The **extensor digitorum brevis** is very evident upon the lateral side of the instep as a firm elevation when the toes are forcibly extended. Its lateral margin is just in front of the groove on the lateral side of the os calcis (*calcaneus*) which transmits the tendon of the peroneus brevis.

The Course of the Arteries and Veins of the Leg.—The popliteal artery divides about two and a half centimeters (one inch) distal to the tubercle (*tuberosity*) of the tibia into the anterior and posterior tibial, the latter giving off the peroneal, about five centimeters (two inches) further down. The point of division of the popliteal artery corresponds to the inferior border of the popliteus muscle. Therefore, one main artery is severed in an amputation two and a half centimeters (one inch) distal to the fibular head (the popliteal); two arteries in amputations five centimeters distal to the fibular head (the anterior and posterior tibials); and three arteries in amputations seven and a half centimeters (three inches) distal to the head of the fibula (the two tibials and the peroneal). The **anterior tibial artery,** after coming forward between the two bones through the interosseous membrane, lies in front of the interosseous membrane near the fibula. Its course down the leg is marked by a line drawn from a point midway between the head of the fibula and the tubercle (*tuberosity*) of the tibia to the middle of the front of the ankle. This line also indicates, quite accurately, the lateral border of the tibialis anterior throughout its length. The pulsations of the artery are readily distinguished as it crosses the front of the distal end of the tibia and the ankle. The **posterior tibial artery** in its course down the leg corresponds to a line extending from the middle of the proximal part of the calf to the center of the fossa bounded by the medial malleolus anteriorly and the os calcis (*calcaneus*) posteriorly, where its pulsations are readily felt about twelve millimeters (one-

half inch) back of the tibial border. In the proximal part of its course the vessel is reached through an incision carried parallel with, and twelve millimeters (half an inch) posterior to the medial border of the tibia.

The Foot.—The **veins of the foot** form an arch across the metatarsus, with its convexity toward the toes. From the medial extremity of the arch arises the *internal*, or *long* (*great*), *saphenous vein* which passes upward anterior to the medial malleolus, thence up the medial side of the leg, posterior to the medial condyle of the femur, and along the medial side of the thigh, gradually moving forward and laterally in its ascent upon the thigh to enter the common femoral vein, after piercing the cribriform fascia covering the saphenous opening (*fossa ovalis*). From the lateral extremity of the arch arises the *external*, or *short* (*small*), *saphenous vein*, which passes posterior to the lateral malleolus, and up the middle of the back of the leg to the popliteal fossa and enters (as a rule) the popliteal vein after piercing the popliteal fascia.

The **bony landmarks of the foot** on the medial side, going forward, are: (1) the medial tuberosity of the os calcis (*calcaneus*); (2) the medial malleolus; (3) two and a half centimeters (one inch) below the malleolus, the sustentaculum tali, for the support of the astragalus (*talus*); (4) the tubercle of the scaphoid (*navicular*), about two and a half centimeters (one inch) in front of and a little below the medial malleolus, the gap between it and the sustentaculum tali being occupied by the calcaneo-scaphoid (*calcaneo-navicular*) ligament and the posterior tibial tendon which sometimes contains a sesamoid bone; (5) the internal (*first*) cuneiform; (6) the prominence of the base of the first metatarsal bone. In the same order, laterally, we find: (1) the lateral tuberosity of the os calcis (*calcaneus*); (2) the lateral malleolus; (3) the tubercle on the peroneal ridge of the os calcis (*calcaneus*), two and a half centimeters below the lateral malleolus, with the short peroneal tendon above, and the long one below it; (4) the prominence of the base of the fifth metatarsal bone.

The **guides to the joints of the foot** are as follows: in *Symes' amputation* of the foot it is to be remembered that the ankle-joint is found twelve millimeters (one-half inch) above the tip of the medial malleolus. In *Chopart's amputation*, a line carried transversely across the tarsus and behind the tubercle of the scaphoid (*navicular*) will locate the astragalo-scaphoid (*talo-navicular*) and calcaneo-cuboid joints. The latter joint is also found on the lateral aspect of the foot midway between the tip of the lateral malleolus and the base of the fifth metatarsal bone. In *Lisfranc's operation* (removal of the metatarsus) the *metatarso-cuneiform joint* is situated three and three-quarters centimeters (an inch and a half) in front of the tubercle of the scaphoid (*navicular*), and the *metatarso-cuboid joint* is just behind the large tubercle upon the base of the fifth metatarsal

bone. The line of the metatarso-phalangeal joints is fully two and a half centimeters (one inch) to the proximal side of the interdigital folds of skin, a fact to be remembered in amputating a toe.

The **dorsalis pedis artery** can be felt pulsating upon the instep on a line drawn from the middle of the ankle to the proximal end of the first interosseous space, along the lateral side of the tendon of the extensor hallucis proprius (*extensor hallucis longus*).

The **plantar arteries** arise at the medial border of the sole of the foot, whence they pass forward; the *external (lateral) plantar artery* runs obliquely lateralward across the foot in a line drawn from a point midway between the medial malleolus and the great tuberosity of the os calcis (*calcaneus*) to the base of the fifth metatarsal bone, thence turning obliquely medialward and forward across the foot near the bases of the metatarsal bones, to join the communicating branch of the dorsalis pedis artery in the first interosseous space. The *internal (medial) plantar artery* runs along a line drawn from the medial side of the os calcis (*calcaneus*) to the middle of the great toe.

The **plantar fascia,** or aponeurosis, is divided to best advantage and with least trouble at its narrowest part, about two and a half centimeters (one inch) in front of its connection with the os calcis (*calcaneus*). This brings the incision behind the plantar arteries, the knife being introduced at the medial side of the foot.

The **tendon of the adductor hallucis** may be severed subcutaneously about two and a half centimeters (one inch) back of its insertion into the medial side of the base of the first phalanx.

The arches of the foot will be fully considered under the anatomy and surgery of the foot.

THE FRONT OF THE THIGH

The body should be placed on its back with a block beneath the loins and the thigh abducted and rotated lateralward to make evident the hollow at its proximal upper and anterior part.

The skin over the proximal, anterior, and medial aspect of the thigh is comparatively thin and delicate. The looseness of its attachment to the parts beneath permits of considerable stretching, except along the groove corresponding to the lateral intermuscular septum of deep fascia which separates the vastus externus (*vastus lateralis*) from the lateral hamstring muscle, in which situation it is a little more adherent. This laxity is well demonstrated in cases of large herniæ and large tumors, and is of advantage surgically in that it favors the performance of circular amputation in this region. In the vicinity of the pubes are numerous

sebaceous and sudoriferous glands, the secretion of which favors the development of intertrigo, or chafing, in the fold of the groin, so often seen in infants and in corpulent individuals.

A few instances of a supernumerary mammary gland in the integument of Scarpa's (*femoral*) triangle are on record. This is a fairly common site for aneurysm, and a more common site for bubo. The two should not be confounded. After deep and severe burns in this region the resulting scars may contract to such an extent as to produce permanent flexion of the thigh. Wounds of the groin, if transverse, can be approximated by flexion of the thigh.

Dissection (Plate CCLXXXVI).—From a point about seven and a half centimeters (three inches) posterior to the anterior superior spine of the ilium carry an incision over the crest of the ilium and along the line of Poupart's (*inguinal*) ligament to the spine (*tubercle*) of the pubis, thence along the fold between the scrotum and the thigh, and from there downward along the medial aspect of the thigh to a point five centimeters (two inches) above the knee; beginning at the latter point the incision is carried transversely across the anterior aspect of the thigh. Turn the skin lateralward in one large flap. To study the structures around the knee, incise the skin transversely seven and a half centimeters (three inches) below the patella, across the anterior half of the leg. Connect the medial ends of this incision and the one above the patella by a longitudinal incision, and reflect this flap of skin lateralward.

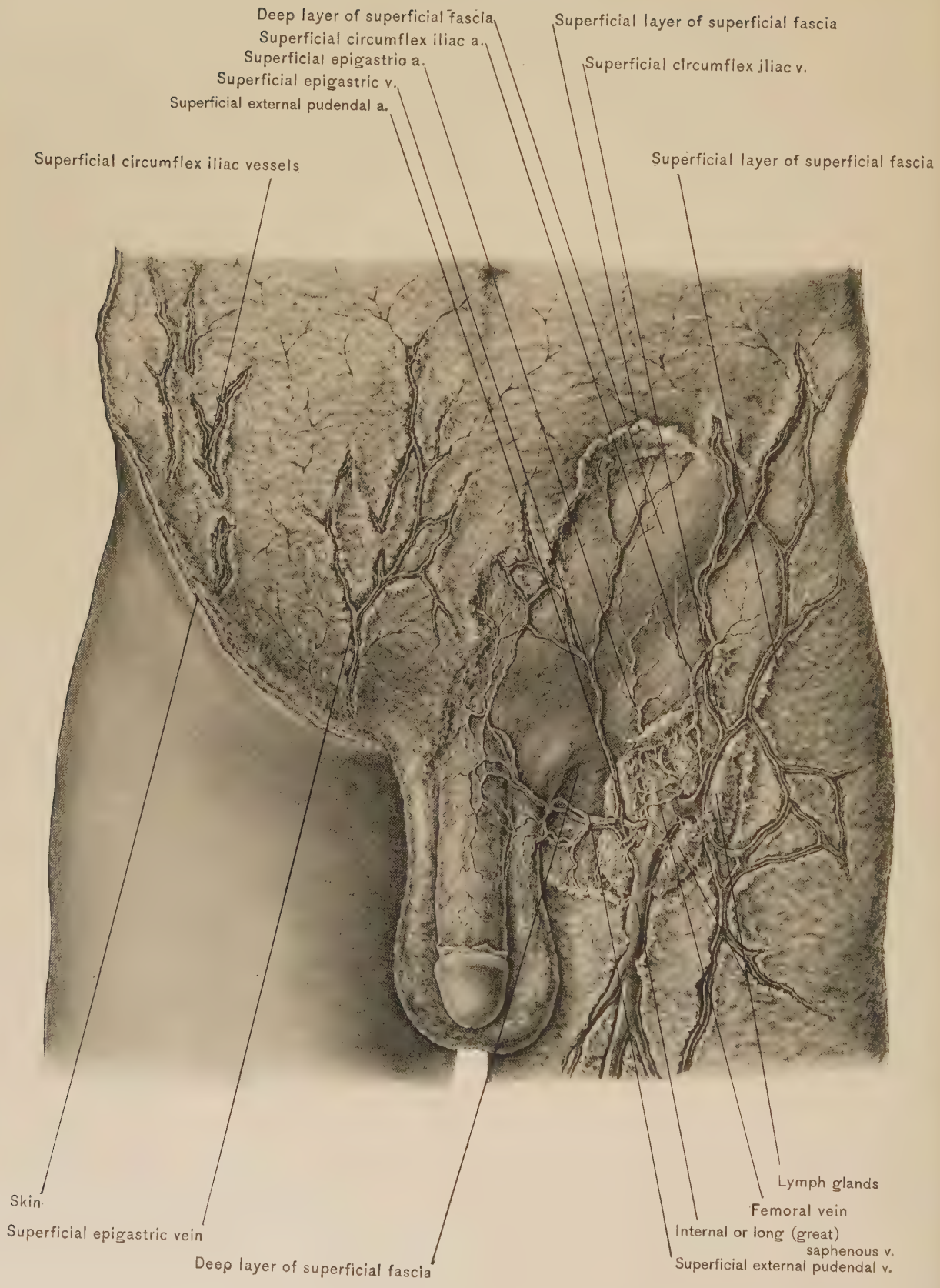
The **superficial fascia** of the anterior aspect of the thigh varies in thickness, the thickest portion being on the medial side, but it is nowhere very dense. It has little or no influence upon the progress of a superficial abscess, as is well illustrated by the readiness with which pus from suppurating glands in Scarpa's (*femoral*) triangle reaches the surface. It consists of two layers, between which are situated the superficial lymph glands and vessels, and the superficial vessels and nerves. In the distal part of the thigh the two layers practically merge into one, and cannot be separated as in the proximal part.

The *superficial layer of the superficial fascia* is continuous with a similar layer of the abdomen, the scrotum (dartos), the perineum, the buttocks, and the legs. Fatty tumors, quite common in Scarpa's (*femoral*) triangle, show a marked tendency to extend downward, the growth of the tumor in that direction being aided by gravity. Such a growth may extend from the groin almost to the knee. The looseness of the capsule of the tumor and the laxity of the tissue in which it lies favor extension. The superficial layer is lax, and permits of extensive extravasations of fluid or of air beneath the skin. This explains the rapid superficial extension of gas in gas gangrene. As the superficial layer of the superficial fascia of the thigh is continuous with that of the abdomen, emphy-

PLATE CCLXXXVI.

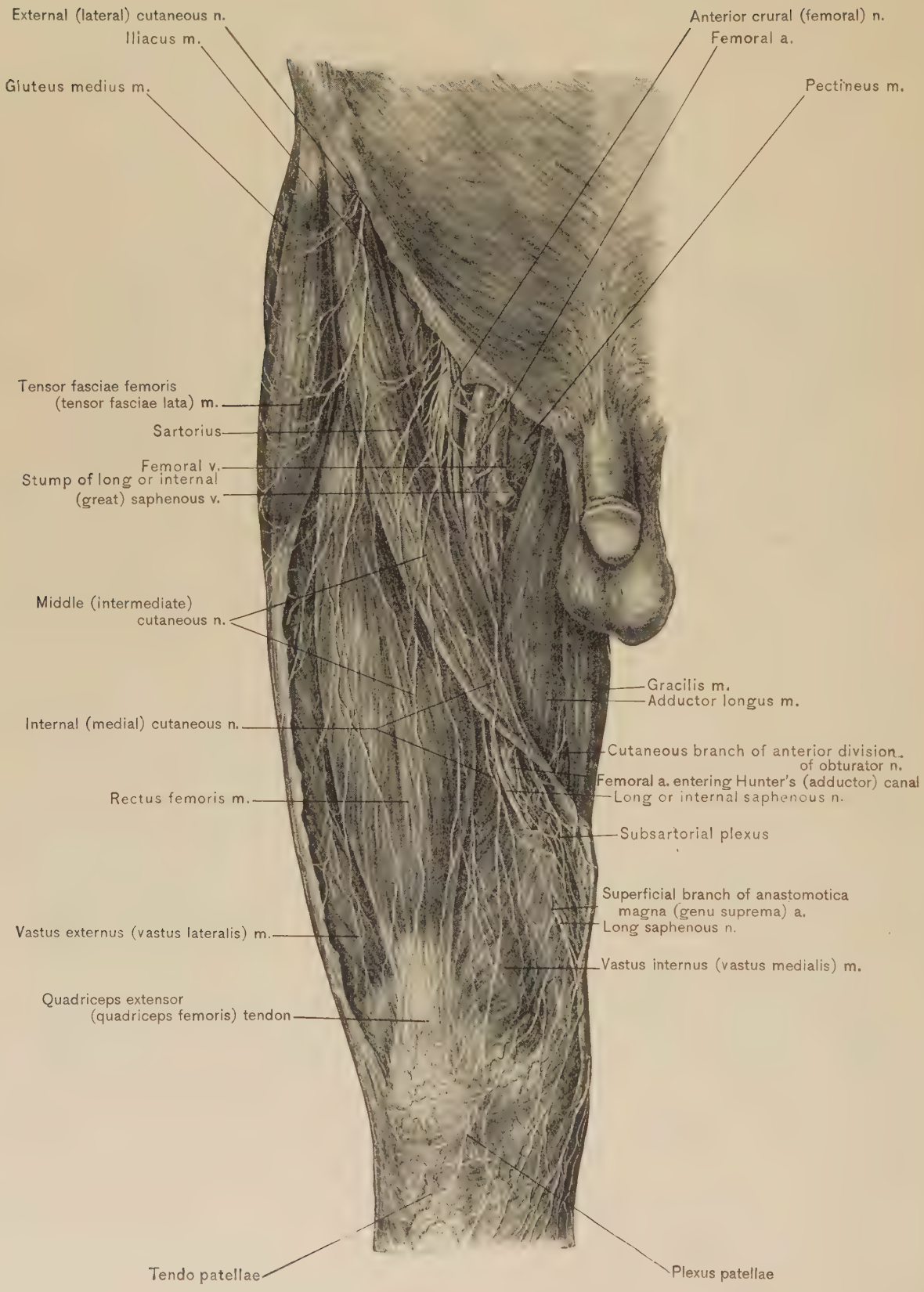
LINES FOR INCISIONS IN DISSECTION.

PLATE CCLXXXVII.



DEEP LAYER OF SUPERFICIAL FASCIA, SUPERFICIAL EPIGASTRIC, AND CIRCUMFLEX ILIAC VESSELS IN ABDOMEN.

PLATE CCLXXXVIII.



MUSCLES, VESSELS, AND NERVES OF FRONT OF THIGH.

sema of the former frequently follows the same condition of the abdomen. This layer of fascia is freely movable over the subjacent layer. Owing to its laxity, a fold of integument can be pinched up over a strangulated femoral hernia and be transfixed, and thus a linear incision be obtained, which does not include either the sac or the intestine. It is safer, however, to make a careful dissection down to the hernial sac.

Dissection.—The superficial layer of the superficial fascia should now be reflected by incisions similar to those made in reflecting the skin. The superficial vessels and nerves and the lymph glands between the two layers form a guide.

The deep layer of the superficial fascia.—(Plate CCLXXXVII.) This layer, unlike the superficial, is attached to the fascia lata (deep fascia) about twelve millimeters (one-half inch) below Poupart's (*inguinal*) ligament. That portion which covers the saphenous opening (*fossa ovalis*), to the margins of which it is closely attached, being pierced by numerous small blood and lymph vessels, is called *cribriform* (sieve-like) *fascia* (*fascia cribosa*); it is carried in advance of a femoral hernia, thus forming one of its coverings.

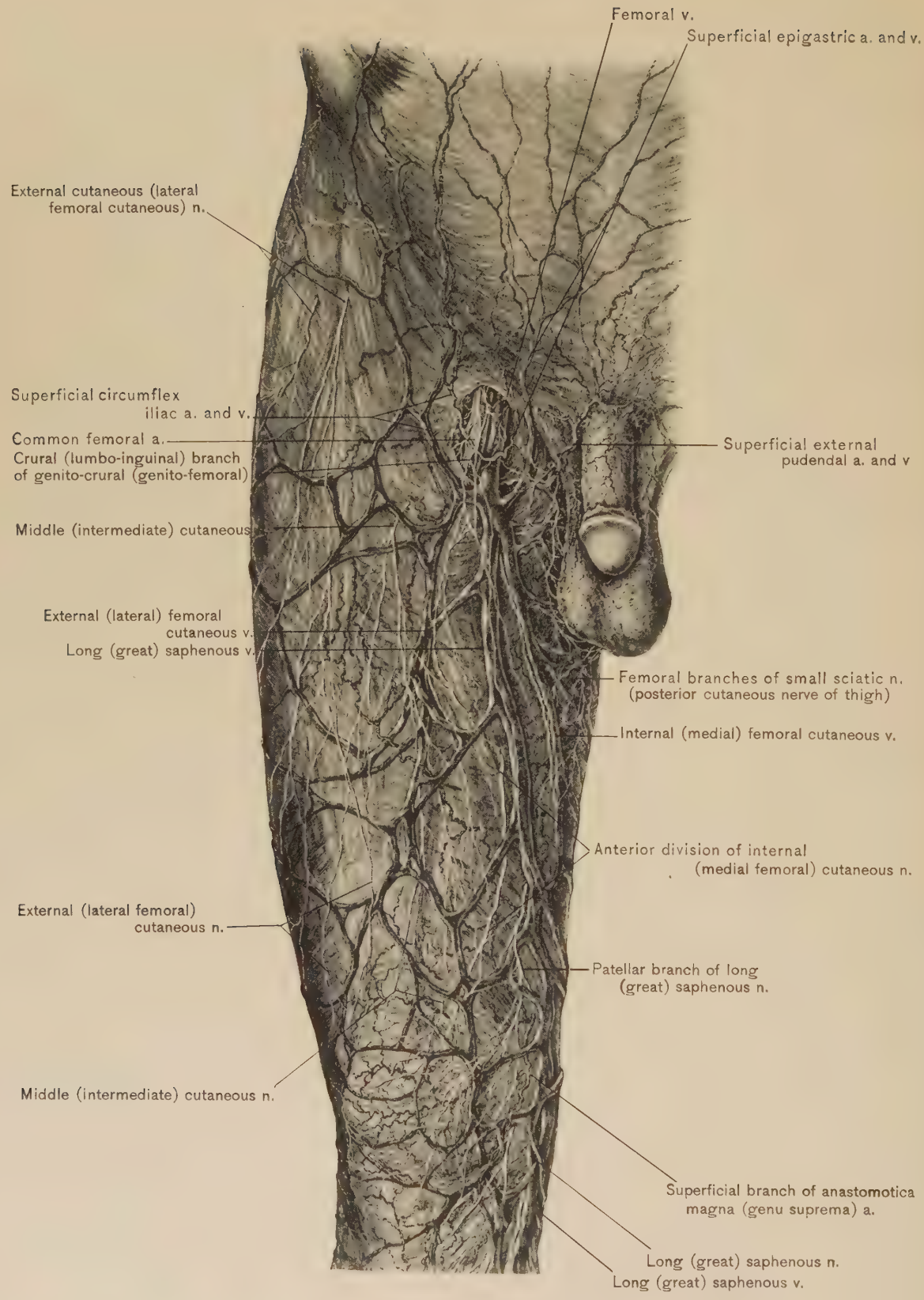
The superficial blood-vessels (Plate CCLXXXVIII).—The vessels occupying the superficial fascia are the superficial epigastric, the superficial external pudendal, and the circumflex iliac arteries, branches of the common femoral (*femoral*) artery, with their accompanying veins, and the long (*great*) saphenous vein. The *superficial epigastric* and *superficial external pudendal arteries* reach the interval between the layers of the superficial fascia by piercing the cribriform fascia which closes in the saphenous opening (*fossa ovalis*); the *superficial circumflex iliac artery* arises either separately or by a common trunk from the common femoral (*femoral*) artery, and usually pierces the deep fascia on the lateral side of the saphenous opening (*fossa ovalis*). The *superficial epigastric artery* passes over Poupart's (*inguinal*) ligament to the lower part of the abdomen and communicates with branches of the deep (*inferior*) epigastric and internal mammary arteries. The *superficial external pudendal* and *superficial epigastric arteries* cross the spermatic cord; the former is distributed to the external genitalia, and anastomoses with branches of the internal pudendal artery, and, as it crosses the cord, with branches of the cremasteric artery. The *superficial circumflex iliac*, the largest of the three branches, passes lateralward to the crest of the ilium, and is distributed to the integument. The accompanying veins of the arteries empty into the long (*great*) saphenous vein.

The **superficial inguinal glands,** which, when enlarged, can be felt through the skin, are exposed in this dissection, and are easily recognized by their oval form and reddish-brown color. They consist of two groups: the superior group

lies along the line of Poupart's (*inguinal*) ligament, and the inferior group lies along the long (*great*) saphenous vein, and occupies, chiefly, the deep layer of the superficial fascia over the saphenous opening (*fossa ovalis*). The superior group receives the lymphatics from the part of the abdominal walls below the umbilicus, from the penis, part of the urethra, the scrotum, the lower part of the vagina and the anal canal, and the upper end of the uterus, the perineum, the buttocks, and the proximal and lateral aspects of the thigh. The inferior group receives the lymphatics from the foot, the leg, and the thigh. The superficial glands send lymph to the **deep glands,** of which there are three or four. They lie at the proximal end of the femoral vein, one of them frequently being found in the femoral canal (gland of Rosenmüller). The deep glands, in turn, send lymph to the glands around the external iliac artery. Of the lymphatics from the lateral side of the foot and leg, some pass with the short (*small*) saphenous vein and empty into the glands of the popliteal space, of which there are about six in number, while others cross to the long (*great*) saphenous vein, which the medial group accompanies, and empty into the inguinal glands. The vessels from all these glands reach the abdomen through the femoral ring. Inflammation of these glands constitutes a bubo. Enlargement of the group along Poupart's (*inguinal*) ligament may simulate an incomplete oblique inguinal hernia, hence the name bubonocele; enlargement of the group over the saphenous opening (*fossa ovalis*) may be mistaken for a femoral hernia. Suppuration of the glands composing the inferior group may demand an incision, which should be made with care owing to the intimate relation which these glands hold to the femoral and long (*great*) saphenous veins. Thorough removal of these glands, in cases of long-standing enlargement associated with sinuses and periglandular infiltration, is a delicate operative procedure, and may lead to serious results unless great care is exercised and the anatomic relations are constantly kept in mind. The femoral vein has been known to be torn during such an operation, necessitating amputation of the thigh. I have seen several further examples since the publication of the first edition of this work. Complete removal of the glands of the groin on both sides of the body may be followed by an extensive and troublesome edema of the external genitalia. However, it is important to remove these as a part of the operation for malignant disease of the penis and anus.

The **long** (**great**), or **internal, saphenous vein,** the chief subcutaneous vein of the lower extremity, ascends along the medial and anterior aspects of the thigh to a short distance below Poupart's (*inguinal*) ligament, where it passes through the cribriform fascia which covers the saphenous opening (*fossa ovalis*) in the fascia lata (deep fascia) to join the common femoral vein. In its course it receives many tributary veins, some of which are often large, especially one which

PLATE CCLXXXIX.


Femoral v.
Superficial epigastric a. and v.
External cutaneous (lateral femoral cutaneous) n.
Superficial circumflex iliac a. and v.
Common femoral a.
Crural (lumbo-inguinal) branch of genito-crural (genito-femoral)
Middle (intermediate) cutaneous
External (lateral) femoral cutaneous v.
Long (great) saphenous v.
Superficial external pudendal a. and v
Femoral branches of small sciatic n. (posterior cutaneous nerve of thigh)
Internal (medial) femoral cutaneous v.
Anterior division of internal (medial femoral) cutaneous n.
External (lateral femoral) cutaneous n.
Patellar branch of long (great) saphenous n.
Middle (intermediate) cutaneous n.
Superficial branch of anastomotica magna (genu suprema) a.
Long (great) saphenous n.
Long (great) saphenous v.

SUBCUTANEOUS VESSELS AND NERVES OF FRONT OF THIGH.

courses around the medial aspect of the thigh and is frequently as large as the main trunk. Just before its termination the long (*great*) saphenous vein is joined by the superficial veins accompanying the superficial arteries of the proximal part of the thigh and lower part of the abdomen. The veins on the lateral side of the thigh sometimes join to form a large trunk, so that occasionally two or three large veins are seen converging toward the saphenous opening (*fossa ovalis*). Like nearly all subcutaneous veins, the long (*great*) saphenous is provided with valves, varying from eight to twenty in number; they are more numerous in the thigh than in the leg, and are situated chiefly at the junctions with the other veins.

Varicose saphenous veins.—A varicose (dilated, tortuous, and thickened) condition of the portion of the long (*great*) saphenous vein below the knee is frequently seen, while the same condition of the entire vein, is occasionally met with. It may result from pressure at the saphenous opening (*fossa ovalis*) caused by a femoral hernia, enlarged glands, etc., or by pressure upon the inferior vena cava or the common iliac veins, or it may follow an accident or phlebitis. It is more frequently met with in individuals who are required to stand for long periods, such as street-car conductors, motormen, etc. A varicosity of the long (*great*) saphenous vein at its entrance into the femoral vein may occur, and may be mistaken for a femoral hernia. It is sometimes necessary to dissect out the entire saphenous vein on account of its varicose condition, but partial excision may suffice in the mild cases. Schede, of Hamburg, recommends a circular incision below the knee through the skin and the superficial fascia, severing all the surface veins, ligating the cut ends above and below, and then closing the circular incision. This operation and that of Trendelenburg, which consists of ligation of the vein just before it empties into the femoral, are practically useless in well-advanced cases. In these a careful dissection of the varicosed veins of the leg and a stripping of the proximal portion of the vein, as suggested by the Mayos, offer the only hope of a permanent cure. In all cases the collateral venous circulation should be tested before operation, otherwise an extensive postoperative edema may result.

The Cutaneous Nerves (Plate CCLXXXIX).—The cutaneous nerves of the thigh are the external cutaneous (*lateral cutaneous*), the middle (*intermediate*) cutaneous, the internal (*medial*) cutaneous, the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*), and the ilio-inguinal nerves.

The **external cutaneous** (**lateral cutaneous**) **nerve,** a branch of the second and third lumbar nerves, enters the thigh beneath Poupart's (*inguinal*) ligament close to the anterior superior spine of the ilium; it passes superficial or deep to the origin of the sartorius, pieces the deep fascia about ten centimeters (four

inches) distal to the anterior superior spine and divides into two branches, an anterior and a posterior. The *anterior branch*, the larger of the two, lies embedded in the fascia lata, emerges from the fascia ten centimeters (four inches) below the ligament, and descends along the anterior and lateral part of the thigh as far as the knee, where it helps to form the patellar plexus, giving off numerous branches. The *posterior branch* pierces the fascia lata (deep fascia) about five centimeters (two inches) below the ligament and divides into branches which are distributed to the integument covering the buttock and the upper and lateral part of the thigh.

The **middle cutaneous** (**intermediate cutaneous**) **nerves,** one or two in number, are given off from the anterior crural (*femoral*) nerve. One usually pierces the sartorius muscle, while the other crosses it; after piercing the fascia lata about ten centimeters (four inches) below Poupart's (*inguinal*) ligament, they descend along the front and medial part of the thigh as far as the knee, distributing branches on either side, inosculating, below, in the patellar plexus with the long saphenous (*saphenous*) and internal (*medial*) cutaneous nerves, and, above, with the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve.

The **internal cutaneous** (**medial cutaneous**) **nerve,** likewise a branch of the anterior crural (*femoral*), passes obliquely across the sheath of the femoral artery at the apex of Scarpa's (*femoral*) triangle, and, after giving off a few cutaneous filaments, divides in front of, or at the medial side of the femoral artery into two branches—an anterior and a posterior. The *anterior branch*, the larger, runs distally in front of the sartorius and perforates the fascia lata at the distal third of the thigh, where it divides into terminal branches; one of these supplies the integument over the medial side of the knee, and the other crosses the patella to supply the lateral side of the knee and to communicate with the long saphenous (*saphenous*) and obturator nerves. It contributes to the patellar plexus. A cutaneous branch accompanying the long (*great*) saphenous vein is sometimes given off from this nerve. The *posterior branch* descends along the posterior border of the sartorius muscle to just proximal to the knee-joint, where it pierces the fascia lata and supplies the integument on the medial side of the leg. It sends filaments to the subsartorial plexus. In cases where the anterior branch of the obturator nerve is very small the medial branch of the internal (*medial*) cutaneous will be found correspondingly large, and vice versa. It is important to note that at the point of election for the ligation of the femoral artery (the apex of Scarpa's (*femoral*) triangle) one (sometimes two) of the branches of the internal (*medial*) cutaneous nerve crosses the sheath of the vessel.

The **patellar plexus,** lying over the anterior aspect of the knee, is formed by the inosculations of the anterior division of the external (*lateral*) cutaneous, the

middle (*intermediate*) cutaneous, the anterior division of the internal (*medial*) cutaneous, and the long saphenous (*saphenous*) nerve.

The **subsartorial plexus** is formed beneath the fascia lata and below the adductor longus at the posterior border of the sartorius muscle by branches of the internal (*medial*) cutaneous, long saphenous (*saphenous*), and obturator nerves.

The **crural branch** (**lumbo-inguinal nerve**) **of the genito-crural** (**genito-femoral**) **nerve** pierces the anterior wall of the femoral sheath, and, immediately below the middle of Poupart's (*inguinal*) ligament, pierces the fascia lata to supply the integument of the anterior aspect of the thigh, where it communicates with the middle (*intermediate*) cutaneous nerve; it distributes a few filaments to the femoral artery under Poupart's (*inguinal*) ligament.

The **ilio-inguinal nerve,** after passing through the external abdominal (*subcutaneous inguinal*) ring, supplies the skin on the medial and proximal aspect of the thigh, a branch also going to the scrotum in the male and to the labium in the female.

Dissection.—Remove the deep layer of the superficial fascia by making incisions similar to those made for the removal of the skin. Reflect it lateralward and expose the deep fascia. In removing that portion of the deep layer of the superficial fascia which closes in the saphenous opening (*fossa ovalis*), the cribriform fascia (*fascia cribrosa*), care must be taken to preserve the margins of that opening to which it is attached. It is also attached to the anterior surface of the sheath of the femoral vessels. Many anatomists regard the cribriform fascia (*fascia cribrosa*) as a thin part of the fascia lata, prolonged from the lateral margins of the saphenous opening (*fossa ovalis*).

The **fascia lata,** or **deep fascia,** one of the most important structures of the body from a surgical standpoint, invests the thigh at all parts. It is attached, above to the outer lip of the crest of the ilium, Poupart's (*inguinal*) ligament, the body of the pubis, the rami of the pubis and ischium, the tuberosity of the ischium, the great sacro-sciatic (*sacro-tuberous*) ligament, the sacrum and coccyx and, behind the femoral vessels, to the capsule of the hip-joint. It is perforated by the superficial circumflex iliac artery, and by the external (*lateral*), middle (*intermediate*), and internal (*medial*) cutaneous nerves. It is thickest and strongest on the lateral side of the limb, where it receives the fibers of the tensor fasciæ femoris (*tensor fasciæ latæ*) muscle and two-thirds of the gluteus maximus muscle. This thickened portion of the fascia extends over the greater trochanter between the crest of the ilium above, and the lateral tuberosity (*condyle*) of the tibia and head of the fibula below, and is known as the **ilio-tibial band** (**ilio-tibial tract**). This band of fascia is an important factor in steadying the pelvis

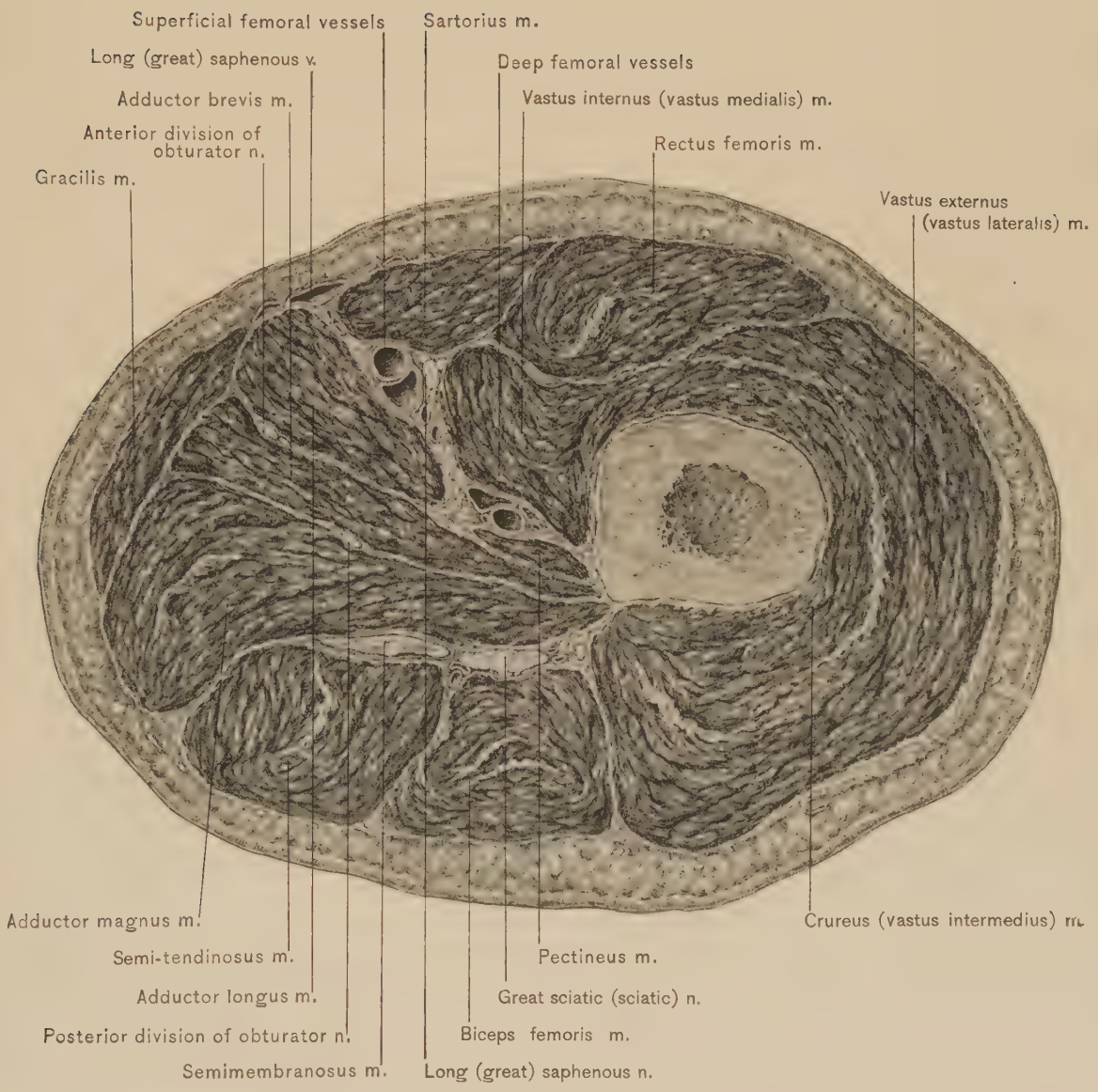
and maintaining the extension of the knee-joint when the body is in the erect position. The portion of the ilio-tibial band between the crest of the ilium and the greater trochanter becomes relaxed in fracture of the neck of the femur, since the greater trochanter approaches nearer the crest of the ilium than normally. The relaxation of the fascia lata at this point is sometimes regarded as of value in the diagnosis of intracapsular fracture of the femur.

The fascia is thinnest at the proximal and medial aspects of the thigh, where it covers the adductor muscles. It increases considerably in strength as it approaches the anterior portion of the knee. At the knee it is attached to the condyles of the femur, the sides of the patella, the medial and lateral tuberosities (*condyles*) of the tibia, and the head of the fibula, thus forming an aponeurotic expansion which serves to protect and strengthen the knee-joint. Around the knee it receives fibrous expansions from the tendon of the biceps femoris laterally, from the sartorius, gracilis, and semitendinosus muscles medially, and from the quadriceps extensor muscles anteriorly. On each side of the thigh it sends in a **muscular septum** (Plate CCXC); each septum being attached to the whole length of the linea aspera and the condyloid ridges. The lateral septum, the stronger, separates the vastus externus (*vastus lateralis*) in front from the biceps femoris muscle behind, and gives partial origin to them; the medial, the thinner one, separates the vastus internus (*vastus medialis*) in front from the adductor muscles behind. In this respect the fascia lata resembles the deep fascia of the arm, from which two processes are sent inward to be attached to the condyloid ridges of the humerus. In the thigh, as in the arm, these septa of fascia divide the limb into two compartments, best seen upon transverse section, but in the lower extremity they are of much less surgical importance than in the upper extremity. Besides the lateral and medial intermuscular septa there are numerous smaller processes separating the individual muscles and inclosing them in separate sheaths. One of these processes, which separates the adductors from the flexors, has been called the **posterior intermuscular septum.**

The three intermuscular septa divide the thigh into three compartments: an anterior, a posterior, and a medial. The *anterior* contains the extensor muscles, the anterior crural (*femoral*) nerve and its branches, the common and superficial femoral and part of the profunda femoris arteries, with their corresponding veins; the *posterior*, the flexor muscles and the great sciatic (*sciatic*) nerve and part of the popliteal vessels and nerves; the *medial* compartment contains the adductor muscles and the obturator vessels and nerves.

The fascia lata, especially at its lateral part, resists the growth of tumors, and the intermuscular septa limit deep extravasations of blood. On account of its density and tenseness it often prevents pus from coming directly to the surface,

PLATE CCXC.



INTERMUSCULAR SEPTA.

so that an abscess beneath it may burrow extensively. A psoas abscess may burrow as far as the knee, and has been known to extend down the leg as far as the tendo Achillis, by the side of which it was opened. A collection of pus caused by disease of the distal end of the femur or pus from a pyarthrosis of the knee-joint may burrow upward. In some cases of abscess beneath the fascia lata on the lateral side of the thigh, after pus has been evacuated, the healing may be slow; repair may be hastened by a subcutaneous section of the fascia covering the cavity, thus favoring collapse and approximation of its wall.

In extravasation, the result of spontaneous rupture of a femoral aneurysm, the blood spreads rapidly in the cellular spaces of the thigh and produces a uniform swelling from the groin to the knee. Such a collection has been opened, with the unexpected result that instead of pus, fluid arterial blood escaped from the puncture. Richet, who dissected the thigh of a subject in which the condition described above had been detected during life, found that the blood had not only infiltrated the muscle interspaces and the cellular tissue, but even the muscle substance itself; but in spite of the enormous pressure which must have been brought to bear to effect such a result, the fascia remained intact. A large swelling of the proximal two-thirds of the medial aspect of the thigh has occurred as the result of hemorrhage from the obturator artery, which simulated an abscess to the extent of presenting all the major symptoms found in such a condition. Contraction of the fascia lata after hip-joint disease, paraplegia, infantile paralysis, etc., may call for division, either of the fascia alone or together with the contracted tendons. The fascia has occasionally been ruptured by violence, and through the rent so formed the subjacent muscle has bulged, forming what is called **hernia of the muscle**; this has been known to involve the quadriceps extensor and adductor longus muscles. Sections of fascia removed from the ilio-tibial tract of the fascia lata have been used in the repair of large ventral and direct herniæ. When a piece of fascia is desired for this purpose the incision should be made along the lateral side of the thigh about seven to ten centimeters (three to four inches) below the greater trochanter, so that that portion of the fascia which receives the fibers of insertion of the tensor fasciæ femoris (*tensor fasciæ latæ*) and the gluteus maximus are not disturbed.

Pubic and iliac portions of the fascia lata.—The fascia lata covering the proximal part of the thigh anteriorly is described as consisting of two portions. The lateral portion is known as the *iliac*, or *sartorial, portion;* the medial, as the *pubic*, or *pectineal, portion*. Between the iliac and pubic portions is the saphenous opening (*fossa ovalis*), through which pass the long (*great*) saphenous vein, to enter the common femoral, lymph vessels, and the superficial epigastric and superficial external pudendal vessels. In addition to this large opening in the

fascia lata, there are numerous small ones through which pass cutaneous nerves and vessels.

The **saphenous opening** (**fossa ovalis**), or **external femoral ring** (Plate CCXCI), is oval in shape and measures about three and three-quarters centimeters (an inch and a half) in length and twelve millimeters (half an inch) in width. It is situated immediately below Poupart's (*inguinal*) ligament at the proximal and medial part of the thigh between the iliac and pubic portions of the fascia lata. It is covered by the cribriform fascia (*fascia cribrosa*) (that portion of the deep layer of the superficial fascia in relation with the opening), which blends with its margins. Its lateral margin, formed by the iliac, or the sartorial, portion of the fascia lata, is semilunar, thin, strong, and sharply defined, and lies on a plane anterior to the femoral vessels. Above, this margin will be seen as a curved process, the superior cornu, or falciform process, which ascends anterior to the femoral vessels, to the sheath of which it is attached by fibrous bands, and becomes continuous with Gimbernat's ligament (*ligamentum lacunare*). The point of junction between the superior falciform process and the base of Gimbernat's ligament (*ligamentum lacunare*) is known as Hey's (*femoral*) ligament and is frequently the seat of stricture in a strangulated femoral hernia. Following the lateral margin downward, it will be seen to be continuous below with a well-defined border, the concavity of which is directed upward; this, the inferior cornu of the saphenous opening (*fossa ovalis*), crosses the femoral vein, lies beneath the long (*great*) saphenous vein and blends with the pectineal, or pubic, portion of the fascia lata. The medial margin of the opening is on a plane posterior to the lateral, and behind the level of the femoral vessels; it is less important and not so well defined as the lateral margin. The tension of the superior cornu is greatly influenced by the position of the limb. Extension, abduction, and lateral rotation of the thigh make the cornu very tense, whereas flexion, adduction, and medial rotation render it lax. Therefore, the latter is the position in which the limb should be placed before attempting the reduction of a femoral hernia.

Dissection.—Remove the fascia lata from the front of the thigh in the same manner as the skin and superficial fascia, and reflect it lateralward as far as the ilio-tibial band of fascia. This necessitates cutting the medial intermuscular septum (do not sever the nerves which pierce the fascia), and exposes: on the medial side of the thigh, the adductor muscles; anteriorly, the sartorius and the quadriceps extensor femoris muscles; above and to the lateral side, the tensor fasciæ femoris (*tensor fasciæ latæ*) and rectus femoris muscles, and the intermuscular space known as Scarpa's (*femoral*) triangle and such of its contents as are superficial.

PLATE CCXCI.

SAPHENOUS OPENING (FOSSA OVALIS), FEMORAL CANAL, AND COMPARTMENTS OF FEMORAL SHEATH.

Boundaries of Scarpa's (femoral) triangle.—This triangle is bounded proximally by Poupart's (*inguinal*) ligament, laterally by the sartorius muscle, and medially by the adductor longus muscle. The base is directed proximally and the apex distally, the latter being formed by the sartorius crossing the adductor longus at the junction of the proximal with the middle third of the thigh. The apex leads to Hunter's (*adductor*) canal. The floor of the triangle slopes backward from each side toward the middle, and is formed, from without medialward, by the iliacus and psoas, the pectineus, and the adductor longus, with sometimes a small portion of the adductor brevis between and beneath the last two muscles mentioned. The roof is formed by the fascia lata and the cribriform fascia (*fascia cribrosa*).

Contents of Scarpa's (femoral) triangle.—This triangle contains: the femoral sheath, including the femoral canal; the common femoral artery with its two terminal divisions, the superficial and deep femoral (*profunda femoris*); the common femoral vein and the two veins which form it, the superficial and deep femoral; the terminal portion of the long (*great*) saphenous vein; the origins of the superficial epigastric, superficial external pudendal, and superficial circumflex iliac, and the deep external pudendal arteries; branches of the common femoral artery; the external (*lateral*) and internal (*medial*) circumflex branches of the deep femoral artery with their veins; the external (*lateral*) cutaneous nerve; the anterior crural (*femoral*) nerve and its divisions, especially the long saphenous (*saphenous*) nerve; the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve, and the accessory obturator nerve when present.

The structures which pass under Poupart's (*inguinal*) ligament, or the crural arch, given in order from the anterior superior spine of the ilium medialward, are: the external (*lateral*) cutaneous nerve close to the anterior superior iliac spine; the iliacus muscle; the anterior crural (*femoral*) nerve; the psoas muscle; the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve; the common femoral artery; the common femoral vein; the lymphatics occupying the three compartments of the femoral sheath; the accessory obturator nerve, when present.

Relations.—Before dissecting further, the femoral sheath having already been opened, note the relations of those contents of Scarpa's (*femoral*) triangle which are seen upon superficial inspection. The femoral vessels, surrounded by their sheath, will be seen to occupy the hollow of the triangular space a little to the lateral side of the center, with the vein to the medial side of the artery. The long (*great*) saphenous vein pierces the sheath to enter the common femoral vein, the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve pierces the anterior wall of the sheath, and the anterior crural

(*femoral*) nerve lies to the lateral side of the artery in the groove between the iliacus and the psoas magnus (*psoas major*) muscles. The long saphenous (*saphenous*) nerve and the nerve to the vastus internus (*vastus medialis*) muscle, both branches of the anterior crural (*femoral*) nerve, are seen lying to the lateral side of the artery. At the apex of the space the artery is crossed by the sartorius muscle and by the internal (*medial*) cutaneous branch of the anterior crural (*femoral*) nerve. At the superior and lateral angle of the space is seen the external (*lateral*) cutaneous nerve.

Surgical importance of Scarpa's (femoral) triangle.—Scarpa's (*femoral*) triangle is significant anatomically on account of the important structures contained therein, and surgically for many reasons, some of which are: that its apex is the point of election for the ligation of the superficial femoral artery; that in this triangle digital pressure is applied to the superficial femoral artery for the cure of popliteal aneurysm; that here the tourinquet is applied to the femoral artery in amputation of the limb below, and that a psoas abscess usually points and a femoral hernia appears in the upper part of the triangle. More recently, the triangle has been exposed in the operation of femoral peri-arterial sympathectomy. The artery can easily be exposed for from five to seven centimeters (two to three inches). It is superficial and its branches are easily seen so that the danger of tearing them is minimized.

The Femoral Sheath.—Situated immediately beneath the saphenous opening (*fossa ovalis*) and its lateral margin are the common femoral artery and vein, surrounded by their sheath, which encloses the first three to four centimeters (one and a quarter to one and seven-eighths inches) of the vessels, and is funnel-shaped, with its apex pointing distally. The anterior portion of the femoral sheath is formed by the extension downward of the transversalis fascia beneath Poupart's (*inguinal*) ligament. The posterior portion is formed by a part of the iliac fascia which reaches the thigh in the same manner as the transversalis, but passes behind the vessels and in front of the psoas and iliacus muscles. These fasciæ are continuous with each other on the lateral side of the artery and on the medial side of the vein. The transversalis fascia just beneath Poupart's (*inguinal*) ligament, where it enters the anterior wall of the femoral sheath, is considerably thickened, forming what is known as the deep crural (*deep femoral*) arch, as distinguished from the crural (*femoral*) arch, or Poupart's (*inguinal*) ligament. The anterior and posterior walls of the femoral sheath are connected by two vertical septa, which divide the sheath into three separate compartments. The lateral septum separates the common femoral artery from the vein; the medial, the vein from the femoral, or crural, canal. The lateral compartment is occupied by the femoral artery; the middle by the femoral vein, and the medial by a lymph gland, a few lymph vessels, and a small amount of connective tissue. The anterior wall

of the sheath is pierced by the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve, the superficial circumflex iliac, superficial epigastric, superficial external pudendal vessels, the long (*great*) saphenous vein, and lymph vessels.

Dissection.—To expose the contents and compartments of the femoral sheath it should be opened by carrying an incision across the front of it, when a trap-door flap consisting of the anterior wall can be raised.

The Femoral Canal.—The medial compartment is known as the femoral, or crural, canal, and is the space between the medial septum and the medial wall of the femoral sheath. It lies on the pectineus muscle under cover of the cribriform fascia (*fascia cribrosa*) and the superior horn of the saphenous opening (*fossa ovalis*). It is funnel-shaped, with its apex below, from twelve or twenty millimeters (one-half to three-fourths of an inch) in length, and extends from the femoral, or crural, ring to the superior margin of the saphenous opening (*fossa ovalis*). It communicates with the abdominal cavity through the femoral ring. In the normal condition the medial compartment of the femoral sheath does not really exist, as the inner wall of the sheath is in almost absolute contact with the septum upon the medial side of the common femoral vein, only a small amount of connective tissue, a lymph gland, and a few lymph vessels intervening. These lymph vessels connect the femoral and the lower group of the inguinal lymph glands with the external iliac glands. To establish the canal, therefore, necessitates separating the medial wall of the sheath from the medial septum by dissection, or by pressure from within. Sometimes the canal may give passage to a loop of intestine, a piece of omentum, or both, constituting a femoral hernia. In a few instances the testicle has been known to pass through it; the author has also found the fimbriated extremity of the Fallopian (*uterine*) tube constituting the contents of the sac in a case of strangulated femoral hernia. The course pursued by a protrusion passing out of the abdomen by way of the femoral ring, would be first through the ring, thence through the canal, and lastly through the saphenous opening (*fossa ovalis*), carrying in advance of it the anterior wall of the femoral sheath. The protrusion passes through the saphenous opening (*fossa ovalis*) because the canal terminates at the superior margin of the opening, and because the sheath is firmly adherent to the inferior and lateral margins of the opening.

The femoral ring is oval in shape with a transverse diameter of about twelve millimeters (one-half inch). Being larger in the female than in the male, femoral hernia is more common in the former. The fact that Gimbernat's ligament (*ligamentum lacunare*) is less firm in the female and occasionally is absent also serves to explain the greater frequency of femoral hernia in women. The femoral ring is bounded anteriorly by Poupart's (*inguinal*) ligament and the deep crura

(*deep femoral*) arch; posteriorly, by the horizontal ramus of the pubis, covered by the pectineus muscle and the pectineal portion of the fascia lata; medially, by the lateral concave margin or base of Gimbernat's ligament (*ligamentum lacunare*) and the conjoined tendon (*falx inguinalis*), and laterally, by the medial of the two vertical septa of the femoral sheath and by the common femoral vein. This opening is closed by the so-called *septum crurale*, derived from the subperitoneal layer of fat which stretches across the ring and extends into the canal; through this covering a few small lymph vessels pass on their way to the external iliac glands. To obtain the best possible idea of the femoral ring, when dissecting the abdomen, pass the finger along the medial side of the external iliac vein and into the ring, when its boundaries can be distinctly felt. Note particularly the tenseness of the medial, and the yielding quality of the lateral margin.

Femoral Hernia.—The saphenous opening (*fossa ovalis*) being the passageway by which a femoral hernia, after having traversed the femoral canal, reaches the thigh, it may be called the external femoral ring, in contradistinction to the internal femoral ring, or ring proper. A hernia which makes its escape from the abdomen through the femoral ring is either complete or incomplete, according to whether it passes into the canal and remains there or makes its exit from the canal through the saphenous opening (*fossa ovalis*). It is the incomplete variety of femoral hernia which, when strangulated, is the more dangerous. This is true, first, for the general reason that in strangulated herniæ the severity of the symptoms usually occur earlier and are more pronounced in small than in large herniæ; secondly, that the swelling, being less marked than in a complete hernia, is much more likely to be overlooked. The direction taken by an incomplete femoral hernia is directly downward, while that of a complete hernia is downward, forward, and upward. In making the turn upward the hernia is brought over the line of Poupart's (*inguinal*) ligament, and therfore, from its position, may simulate an inguinal hernia. The spine (*tubercle*) of the pubis is the land-mark by which they can be differentiated. A femoral hernia is always acquired, differing in this respect from inguinal and some other forms of hernia which are often congenital.

The **coverings of a femoral hernia** are skin, superficial fascia, cribriform fascia (*fascia cribrosa*), sheath of the vessels, the septum crurale (subperitoneal fat), and peritoneum, the last forming the innermost covering, or sac, of every hernia. What has been said regarding the difficulty in recognizing the different coverings when operating for strangulated inguinal hernia applies also to femoral hernia; in non-strangulated hernia, however, the coverings are usually recognizable.

The **fascia propria** of Cooper, which is sometimes given as one of the coverings of a femoral hernia, is another name for the thickened portion of the

subperitoneal layer of fat, mentioned above as the septum crurale, and matted together with the anterior wall of the femoral sheath. It may assume a membranous appearance from the pressure of the hernia. It is of importance, since from its membranous appearance it may be mistaken for the peritoneum. But it has not the arborescent arrangement of the vessels seen in the latter, and when incised, the fatty portion is exposed; this may be mistaken for omentum, and may still further puzzle the inexperienced surgeon.

The relief of constriction in femoral hernia.—The seat of constriction in a strangulated femoral hernia is either Gimbernat's ligament (*ligamentum lacunare*) or Poupart's (*inguinal*) ligament or the neck of the sac. In dividing any one of these, the following relations should be borne in mind: the spermatic cord or the round ligament lies immediately above the superior boundary of the femoral ring; the deep epigastric (*inferior epigastric*) artery lies along its superior and lateral border; the pubic branch of the deep epigastric (*inferior epigastric*) passes round its superior and medial margins. In thirty-seven cases out of one hundred and one collected by Quain, the obturator artery arose from the deep epigastric (*inferior epigastric*), and to reach the obturator foramen passed along the lateral margin of the ring, while in ten cases it passed superior to the ring and along its medial margin. Again, when the obturator artery lies to the medial side of the ring, it is accompanied by the pubic vein on its way to the external iliac vein. The incision for the relief of the constriction should be made upward and slightly medialward to avoid the common femoral vein and the deep epigastric (*inferior epigastric*) artery. To avoid hemorrhage, of which several fatal cases have been recorded, the hernia knife should not be too sharp. If the constriction lies in the neck of the sac, it should be relieved after the sac has been opened. The fluid in the sac should be removed before returning the bowel to the abdomen, since it contains highly toxic products.

Taxis in femoral hernia.—For the successful reduction of a femoral hernia by taxis, the thigh should be flexed and rotated slightly medialward, thus relaxing the superior and lateral margins of the saphenous opening (*fossa ovalis*). As the hernia, if complete, will present along, if not over Poupart's (*inguinal*) ligament, it should first be carried downward to the saphenous opening (*fossa ovalis*), pushed backward through the opening, and then upward through the femoral canal. By this manipulation the contents of the rupture are made to take a course the reverse of that by which they reached the thigh. The sac of the hernia is not reducible unless of very recent origin, before sufficient time has elapsed for the formation of adhesions between its outer coat and the surrounding structures.

The **sartorius,** a narrow, flat muscle, the longest in the body, is superficial throughout, and extends from the pelvis to the leg. It *arises* from the anterior

superior spine of the ilium and the ridge of bone inferior to it for about two and a half centimeters (one inch). It passes obliquely over the anterior surface to the medial side of the thigh and descends upon the roof of Hunter's (*adductor*) canal in the groove between the vastus internus (*vastus medialis*) on the lateral side and the adductor longus and magnus muscles on the medial side. It then crosses the adductor magnus and terminates in a flat tendon which passes behind the medial condyle of the femur, over the internal lateral (*tibial collateral*) ligament of the knee-joint, and expands into a broad aponeurosis which covers the tendons of the gracilis and semitendinosus, and is *inserted* into the proximal part of the medial surface of the shaft of the tibia and the deep fascia of the leg, anterior to the gracilis and the semitendinosus. This tendon is described by some anatomists as one of the medial hamstring tendons. From the proximal margin of the tendinous expansion an offset is derived which blends with the tendon of the quadriceps extensor (*quadriceps femoris*) covering the knee and with the capsule and the internal lateral (*tibial collateral*) ligament. A bursa is interposed between the tendinous expansion and the tendons of the gracilis and semitendinosus, and a larger one between the tendon and the internal lateral (*tibial collateral*) ligament of the knee-joint. Either of these bursæ may become enlarged, particularly the former, in horseback riders. The sartorius in its course crosses the rectus femoris, iliacus, psoas, pectineus, vastus internus (*vastus medialis*), adductor longus, and adductor magnus muscles, the anterior crural (*femoral*) nerve, the sheath of the femoral vessels, the long (*great*) saphenous nerve, the medial condyle of the femur, the internal lateral (*tibial collateral*) ligament of the knee-joint, and the tendons of the gracilis and semitendinosus muscle. It is frequently pierced at its proximal part by a division of the middle (*intermediate*) cutaneous nerve, and near the knee is crossed by the anterior branch of the internal (*medial*) cutaneous nerve and the long (*great*) saphenous vein, the deep fascia intervening between the muscle and the vein.

The sartorius is the guide to the superficial femoral artery when ligating it both at the apex of Scarpa's (*femoral*) triangle and in Hunter's (*adductor*) canal, at both of which points the muscle is displaced lateralward.

In Barker's operation, which is still a standard after many years, the hip-joint is excised through an incision carried along the lateral border of the sartorius distal to its origin, striking off the interval between it and the tensor fasciæ femoris (*tensor fasciæ latæ*). The incision is carried distally and slightly medialward for seven to ten centimeters (three to four inches). The sartorius and rectus femoris muscles are retracted medialward. The joint capsule is then exposed.

The sartorius has been known to be ruptured, but from its length and peculiar action this would not ordinarily be expected. The tendons of the sar-

PLATE CCXCII.

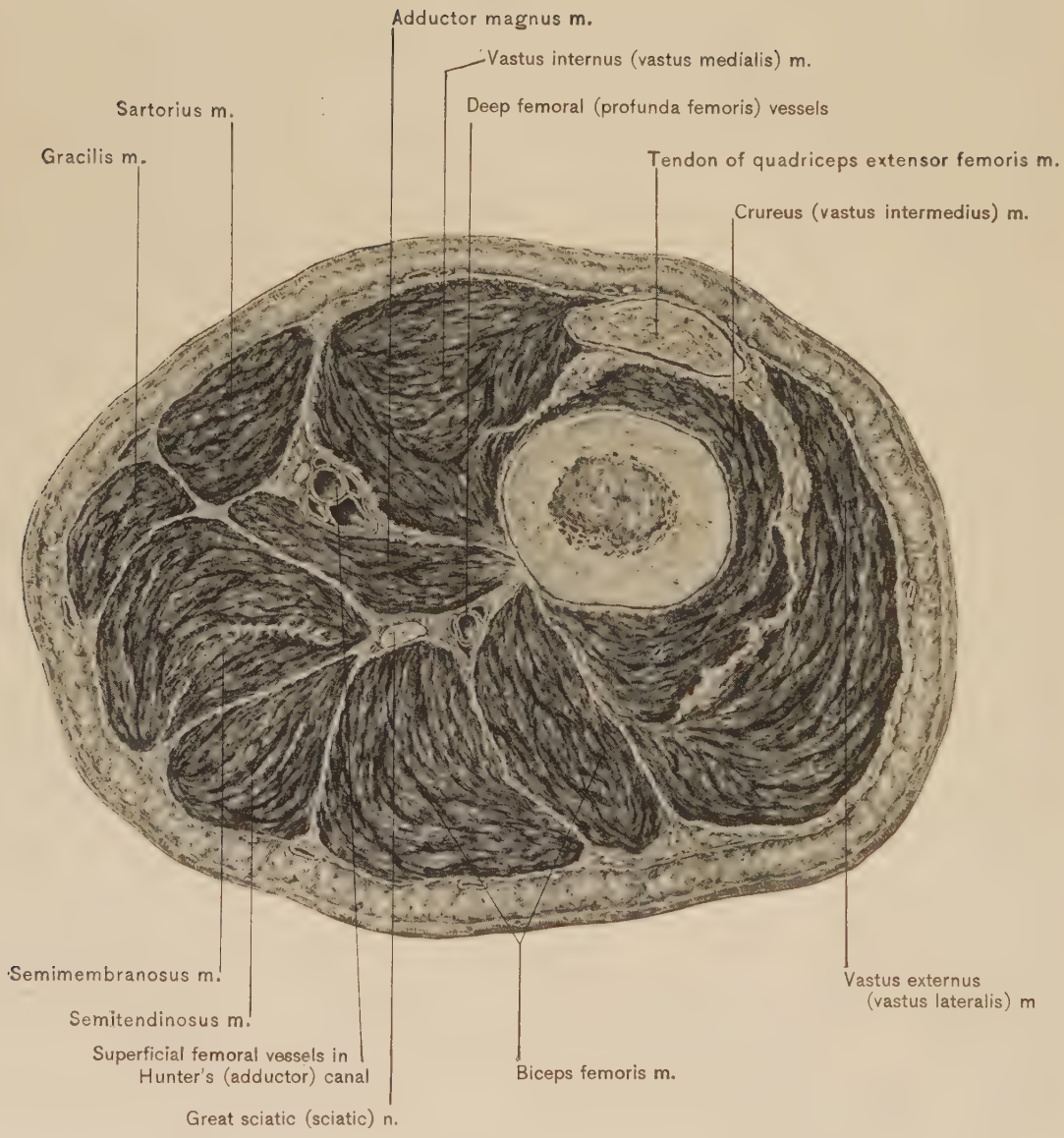


DIAGRAM OF HUNTER'S (ADDUCTOR) CANAL.

PLATE CCXCIII.

Cutaneous branch of anterior division of obturator n.
Long (great) saphenous n.
Gracilis m.
Sartorius m.
Internal (medial) cutaneous n.
Femoral a. entering Hunter's (adductor) canal
Rectus femoris m.
Adductor magnus m.
Subsartorial plexus
Roof of Hunter's (adductor) canal
Semimembranosus m.
Vastus internus (vastus medialis) m.
Femoral a. leaving Hunter's (adductor) canal
Articular branch of the obturator n. to the knee joint
Articular branch of the nerve to the vastus internus (vastus medialis) m.
Plexiform popliteal v.
Insertion of sartorius m.
Long saphenous (saphenous) n.
Superficial branch of anastomotica magna (genu suprema) a.
Piercing the roof of Hunter's (adductor) canal

HUNTER'S (ADDUCTOR) CANAL AND CONTAINED STRUCTURES.

torius and gracilis are the landmarks in finding the long saphenous (*saphenous*) nerve at the medial side of the knee, where the nerve, in company with the superficial branch of the anastomatica magna (*genu suprema*) artery, pierces the deep fascia between these tendons.

Nerve Supply.—The sartorius receives its nerve supply from the middle (*intermediate*) cutaneous branch of the anterior crural (*femoral*) nerve.

Action.—The sartorius flexes the leg upon the thigh and the thigh upon the abdomen. It rotates the thigh lateralward and abducts it; when the knee is flexed, it rotates the leg medialward. If the legs are fixed, the two muscles acting together would flex the pelvis upon the thighs. When standing upon one leg, it assists in rotating the body, carrying its side of the pelvis forward. Its chief action, however, is to steady the pelvis upon the thigh.

Hunter's (Adductor) Canal.—By displacing the sartorius lateralward, a dense aponeurotic lamina, ten to twelve centimeters (four to five inches) in length, extending from the apex of Scarpa's (*femoral*) triangle proximally, to the opening in the adductor magnus distally, will be seen upon the medial aspect of the middle third of the thigh. This lamina is the roof of Hunter's (*adductor*) canal which stretches from the vastus internus (*vastus medialis*) on the lateral side, to the adductor longus and magnus on the medial side. It is pierced by the long saphenous (*saphenous*) nerve and the superficial branch of the anastomotica magna (*genu suprema*) artery.

Dissection.—Divide the roof of Hunter's (*adductor*) canal without injuring the long saphenous (*saphenous*) nerve and the anastomotica magna (*genu suprema*) artery.

Hunter's (*adductor*) canal is a trough-shaped space about ten centimeters (four inches) in length in the middle third of the thigh, extending from the apex of Scarpa's (*femoral*) triangle to the opening in the adductor magnus. It is bounded laterally by the vastus internus (*vastus medialis*), medially and anteriorly by the roof, and posteriorly by the adductor longus and mangus. It contains the superficial femoral artery and vein, the long saphenous (*saphenous*) nerve, and the anastomotica magna (*genu suprema*) artery. (Plates CCXCII; CCXCIII.)

The Femoral Arteries are the common, the superficial, and the deep femoral (*profunda femoris*).

The **common femoral** is the continuation of the external iliac artery, and begins behind Poupart's (*inguinal*) ligament, midway between the anterior superior iliac spine and the symphysis pubis. It passes distally in Scarpa's (*femoral*) triangle for about five centimeters (two inches) and gives off the deep femoral (*profunda femoris*) and is continued as the superficial femoral. The point

of division, in about three-fourths of the cases, is between two and a half and five centimeters (one and two inches) below Poupart's (*inguinal*) ligament.

The **superficial femoral artery** consists of two portions, the one, the superficial portion, occupying Scarpa's (*femoral*) triangle, and the other, the deep portion, situated in Hunter's (*adductor*) canal. The superficial femoral being the continuation of the common femoral, a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle, or the most prominent part of the medial condyle, the limb being in the position of slight lateralward rotation and abduction, would represent the course of both vessels.

Relations of the Common Femoral Artery.—Anterior to it are the crural branch (*lumbo-inguinal nerve*) of the genito-crural (*genito-femoral*) nerve, the anterior portion of the sheath of the femoral vessels, the iliac portion of the fascia lata (deep fascia), the superficial epigastric artery and vein, and the superficial circumflex iliac vein. Posterior to it are the posterior portion of the sheath of the vessels, the pubic portion of the fascia lata, the nerve to the pectineus, the psoas and pectineus muscles, and the capsular ligament of the hip-joint. On the medial side are the common femoral vein and the septum between the artery and vein. On the lateral side are the anterior crural (*femoral*) nerve and its branches at their origin.

Although the artery lies over the medial part of the head of the femur, it is not easily compressed at that point because the vessel is likely to slip from under the finger on account of the mobility of the head of the bone. Compression is more easily made against the horizontal ramus of the pubis. In view of the relation of the vessel to the head of the femur, the latter can be located by the pulsations of the vessel. This is important in the diagnosis of fracture of the neck of the bone and in determining whether or not union has taken place.

Relations of the Superficial Portion of the Superficial Femoral Artery.—Anterior to it are the posterior branch of the internal (*medial*) cutaneous nerve, the sartorius muscle, and the fascia lata. Posterior to it are the profunda vessels, the pectineus muscle, and the fascia lata. Posterior and to the medial side, at the apex of Scarpa's (*femoral*) triangle, is the superficial portion of the superficial femoral vein. On the lateral side are the long saphenous (*saphenous*) nerve and the nerves to the vastus internus (*vastus medialis*) and the vastus externus (*vastus lateralis*). The distance of the artery from the surface increases as it descends. The proximity of the artery to the surface in the superficial portion of its course renders its pulsations visible when the limb is extended, and makes it readily accessible both for pressure and ligation. The superficial femoral artery gives off branches to the sartorius and vastus internus (*vastus medialis*) muscles in Scarpa's (*femoral*) triangle.

Dissection.—To expose the deep portion of the superficial femoral artery, the structures in Hunter's (*adductor*) canal should be carefully dissected.

Relations of the Deep Portion of the Superficial Femoral Artery.—Anterior to it is the long saphenous (*saphenous*) nerve, the roof of the canal, the vastus internus (*vastus medialis*), and the sartorius. Posterior to it are the adductor longus and magnus, and at the proximal part of the canal the deep portion of the superficial femoral vein; while distally, the vein lies to the lateral side. On the lateral side are the vastus internus (*vastus medialis*), the long saphenous (*saphenous*) nerve in the proximal part of the canal, and the deep portion of the superficial femoral vein in the distal part of the canal. On the medial side are the adductor longus and magnus, the junction of the roof of the canal with these muscles, and the long saphenous (*saphenous*) nerve in the distal part of the canal.

The **branches of the common femoral** are the superficial epigastric, superficial external pudendal, superficial circumflex iliac, deep external pudendal, and the profunda femoris arteries. The three superficial vessels have already been described with the superficial fascia.

The **deep external pudendal artery** passes medialward over the pectineus beneath the pubic, or pectineal, portion of the fascia lata, which it pierces at the ramus of the pubis. It supplies the pectineus, the scrotum in the male, and the labium in the female. It anastomoses with the superficial perineal (*perineal*) artery.

The **superficial femoral artery** is the continuation of the common femoral.

The *branches of the superficial portion* of the superficial femoral artery are the muscular and the saphenous. The muscular branches supply the sartorius, rectus femoris, and vastus internus (*vastus medialis*) muscles.

The *branches of the deep portion* of the superficial femoral artery are the anastomotica magna (*genu suprema*) artery and muscular branches.

The **anastomotica magna** (**genu suprema**) **artery** arises from the deep portion of the superficial femoral just before it leaves Hunter's (*adductor*) canal. It divides into a superficial and a deep branch. The *superficial* (*saphenous*) *branch* pierces the roof of Hunter's (*adductor*) canal, accompanies the long saphenous (*saphenous*) nerve beneath the sartorius and between the tendons of the sartorius and gracilis, pierces the deep fascia, and supplies the integument of the proximal and medial part of the leg. It anastomoses with the inferior internal articular (*medial inferior genicular*) artery and the recurrent branch of the anterior tibial artery. The *deep branch* enters the vastus internus (*vastus medialis*) through the substance of which it passes, in front of the tendon of the adductor magnus muscle, to the knee, where it anastomoses with the superior and inferior internal

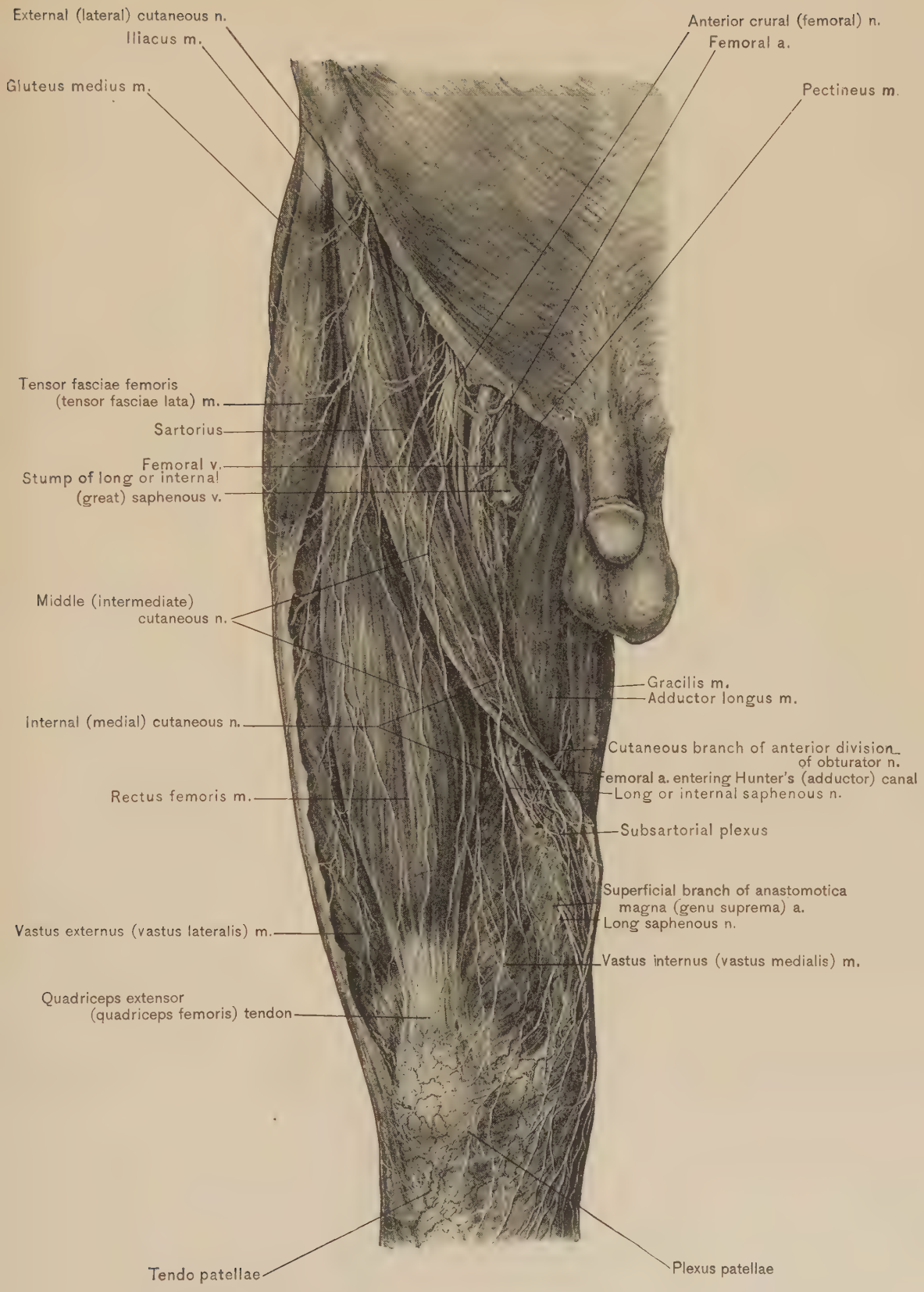
articular (*medial superior and medial inferior genicular*) arteries and the recurrent branch of the anterior tibial. A branch of considerable size passes lateralward above the patella, and, with the superior external articular (*lateral superior genicular*) artery, forms the anastomotic arch, from which branches are given off to supply the knee-joint. The anastomatica magna (*genu suprema*) artery gives off *muscular branches* to supply the adjacent muscles. (Plate CCXCIV.)

Anomalies of the femoral artery.—A few cases are recorded of double superficial femoral arteries; also cases where the common femoral, as the continuation of the sciatic or the internal iliac artery, passes out of the pelvis through the great sacro-sciatic notch and accompanies the great sciatic (*sciatic*) nerve to the popliteal space, where it continues as the popliteal. In such cases the external iliac artery ends in the profunda femoris artery or some other of the usual branches of the common femoral artery. There may occasionally be present an artery connecting the external iliac with the femoral artery, running by the medial side of those vessels.

The **deep femoral** (**profunda femoris**) **artery** (Plate CCXCV), the main nutrient vessel of the thigh, comes off from the lateral and posterior part of the common femoral, two and a half to five centimeters (one to two inches) below Poupart's (*inguinal*) ligament. It has been seen to arise less than two and a half centimeters (one inch) below the ligament, even opposite to the ligament, and occasionally above the ligament, from the external iliac. It occasionally arises more than five centimeters (two inches) below the ligament; at times it arises at as great a distance as ten centimeters (four inches) below the ligament. When the common femoral artery arises from the sciatic (*inferior gluteal*) or the internal iliac artery, the deep femoral artery is usually the direct continuation of the external. In the first five centimeters (two inches) of its course it lies to the lateral side of the superficial femoral artery. It then passes downward and medialward behind the deep femoral vein, the adductor longus muscle, and the superficial femoral artery and vein, to reach the medial side of the femur. It terminates at the distal third of the thigh in a small branch, the fourth perforating, which pierces the adductor magnus. It supplies the adductor and flexor muscles.

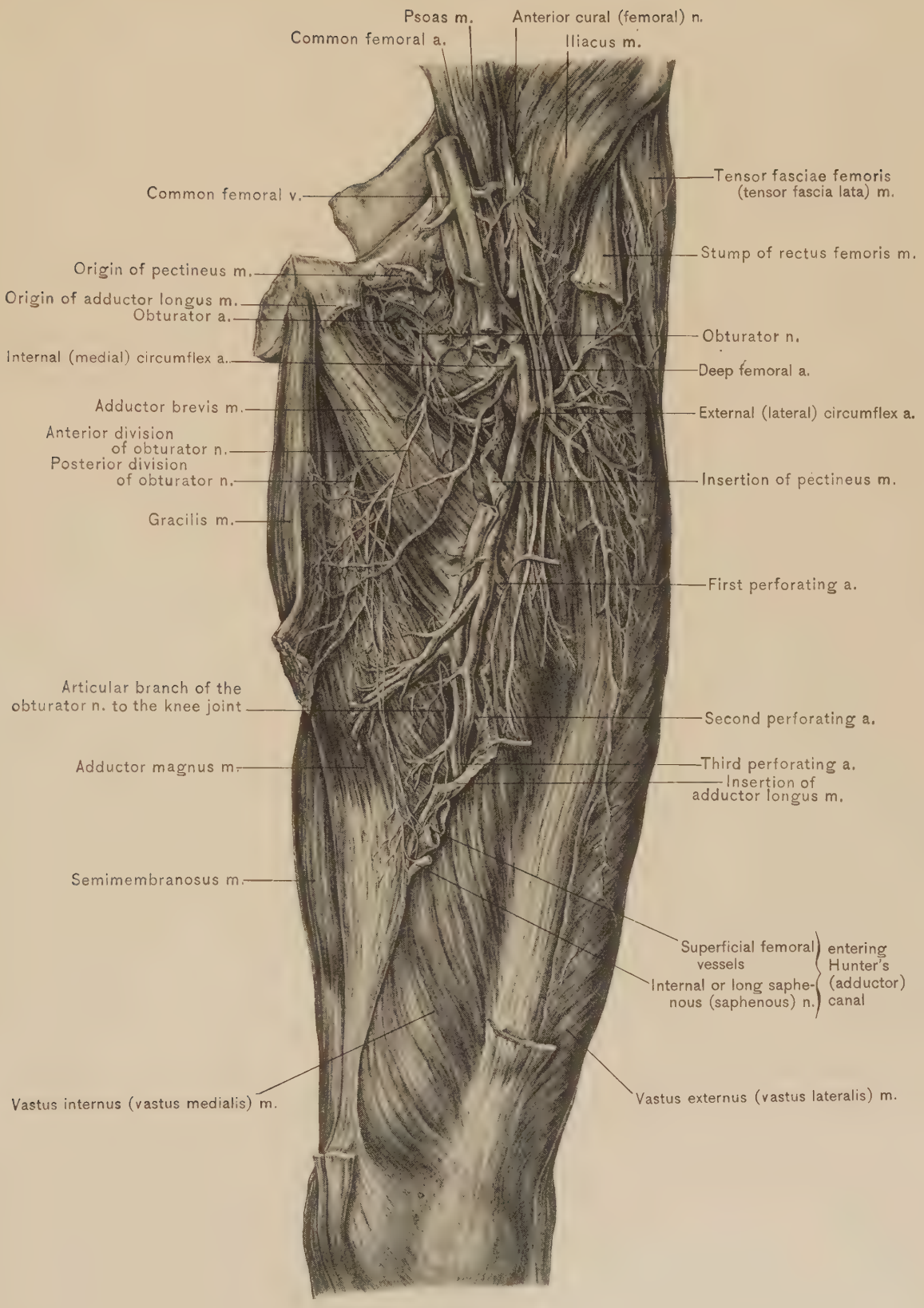
Relations of the Deep Femoral, or Profunda Femoris, Artery.—It lies upon the iliacus, pectineus, adductor brevis, and adductor magnus muscles. It is separated from the superficial femoral artery above by the superficial and deep femoral veins, and below by the tendon of the adductor longus. Lateral to the artery are the vastus internus (*vastus medialis*) and the angle of junction of the adductor longus with the adductor brevis and magnus. On the medial side are the pectineus, the adductor brevis, and the adductor magnus. In the first part

PLATE CCXCIV.



MUSCLES, VESSELS, AND NERVES OF FRONT OF THIGH.

PLATE CCXCV.



DEEP FEMORAL ARTERY AND OBTURATOR NERVE.

of its course, where it lies laterally but on a plane posterior to the superficial femoral, it has been mistaken for that artery (Holden). Here it is covered by branches of the anterior crural (*femoral*) nerve and the deep fascia.

The branches of the profunda femoris are the internal (*medial*) and external (*lateral*) circumflex, and the three perforating arteries.

The **external (lateral) circumflex artery** arises from the lateral side of the profunda, about twenty millimeters (three-fourths of an inch) distal to the origin of that vessel, passes transversely lateralward over the iliacus muscle between the branches of the anterior crural (*femoral*) nerve beneath the sartorius and rectus muscles, and divides into three sets of branches: ascending, transverse, and descending. The *ascending branches* run to the lateral side of the ilium beneath the sartorius, tensor fasciæ femoris (*tensor fasciæ latæ*), and gluteus medius muscles, and anastomose with the gluteal (*superior gluteal*) and deep circumflex iliac arteries. The *transverse branches* pass directly lateralward between the rectus and crureus (*vastus intermedius*) and pierce the vastus externus (*vastus lateralis*). They reach the posterior portion of the thigh and anastomose with the internal (*medial*) circumflex, sciatic (*inferior gluteal*), and superior perforating arteries to form the **crucial anastomosis.** The *descending branches*, two or three in number and of considerable size, run beneath the rectus and between the crureus (*vastus intermedius*) and vastus externus (*vastus lateralis*) to which they are distributed. The longest branch runs in the substance of the vastus externus (*vastus lateralis*) and anastomoses with the superior external articular (*lateral superior genicular*) branch of the popliteal. This branch reaches the lateral side of the knee, where it is accompanied by the nerve to the vastus externus (*vastus lateralis*) muscle.

The **internal (medial) circumflex artery** arises from the medial and posterior part of the profunda opposite the external (*lateral*) circumflex, and runs backward between the psoas and pectineus; next, between the obturator externus and the proximal border of the adductor magnus; and then between the adductor magnus and quadratus femoris. Deep in the thigh it sends a branch upward to supply the adductors and the obturator externus, accompanying the latter muscle to the digital (*trochanteric*) fossa. It anastomoses with the obturator artery. Another branch descends between the adductor brevis and magnus in relation with the posterior branch of the obturator nerve. The terminal portion of the vessel, which will be exposed in the dissection of the back of the thigh, will be seen emerging from between the quadratus femoris and the proximal portion of the adductor magnus. It takes part in forming the so-called crucial anastomosis (see above). Opposite the hip-joint, the internal (*medial*) circumflex sometimes gives off an articular (*acetabular*) branch which enters the joint through the acetabular notch

beneath the transverse ligament and runs along the ligamentum teres to supply the synovial membrane and the head of the bone.

The circumflex arteries may vary in their origin. Sometimes they arise separately from the common femoral above the profunda. The external (*lateral*) circumflex may be double; and the internal (*medial*) circumflex may be a branch of the external iliac artery, or of one of its branches.

The **perforating arteries of the profunda,** four in number, are so called because they perforate the tendons of the adductors brevis and magnus, winding round the back of the femur to reach the back of the thigh and end in the vastus externus (*vastus lateralis*). They supply the muscles which they pierce, and the flexors, the vastus externus (*vastus lateralis*), the vastus internus (*vastus medialis*), and the gluteus maximus.

The *first,* or *superior, perforating artery* passes backward between the pectineus and adductor brevis, and pierces the adductor magnus near the bone. It sends a branch upward beneath the gluteus maximus, which anastomoses with the internal (*medial*) and external (*lateral*) circumflex and the sciatic (*inferior gluteal*) to form the crucial anastomosis, and another downward to anastomose with the middle perforating artery.

The *second,* or *middle, perforating artery,* the largest, arises between the adductor longus and adductor brevis. It pierces the adductors brevis and magnus muscles near the linea aspera, and divides into an ascending and a descending branch which anastomose, respectively, with the superior and inferior perforating arteries. The nutrient artery of the femur is usually a branch of this artery, but occasionally arises from the third perforating artery.

The *third,* or *inferior, perforating artery* arises between the adductors longus and magnus near the distal border of the adductor brevis. It pierces the adductor magnus near the linea aspera and divides into an ascending and a descending branch which anastomose, respectively, with the second perforating artery above, and the fourth perforating, and muscular branches of the popliteal artery below.

The *terminal portion of the profunda,* or *fourth perforating artery,* pierces the adductor magnus just above the exit of Hunter's (*adductor*) canal. It anastomoses with the third perforating artery and with muscular and superior articular (*superior genicular*) branches of the popliteal.

Anastomoses of the Common and Deep Femoral Arteries.—Should the external iliac artery be obliterated or ligated blood may reach the femoral vessels by means of the anastomoses of the iliac arteries. The deep (*inferior*) epigastric branch anastomoses with the superior epigastric branch of the internal mammary and with the lower aortic intercostals and lumbar arteries. The deep circumflex iliac, through its lateral and ascending epigastric branches, anastomoses with the

lumbar arteries and also makes connections with the ilio-lumbar and gluteal branches of the internal iliac. The pubic branches of the deep (*inferior*) epigastric anastomose with those of the obturator artery, a branch of the internal iliac. Blood may also reach the femoral by way of the anastomoses between the superficial and deep epigastrics and the superficial and deep circumflex iliacs and the gluteal (*superior gluteal*). Any existing connection of the external and internal pudendals would also assist in forming a collateral circulation.

Should the femoral artery be ligated above the origin of the deep femoral (*profunda femoris*), collateral circulation may be established by union of the branches of that vessel with the sciatic (*inferior gluteal*) in the crucial anastomosis, and by the connections of the external (*lateral*) circumflex, the gluteal (*superior gluteal*) and the deep circumflex iliac. If the vessel is ligated below the origin of the profunda, the circulation of the lower extremity will be maintained through the anastomosis around the knee-joint (*geniculate anastomosis*). Here the descending branch of the external (*lateral*) circumflex and the fourth perforating artery anastomose with the anastomotica magna (*genu suprema*).

Crucial Anastomosis.—This is formed proximodistally by the (1) gluteal (*superior gluteal*), (2) the muscular and perforating branches of the profunda, (3) the proximal muscular branches of the popliteal, and (4) the branches of the external (*lateral*) and internal (*medial*) circumflex arteries.

The Femoral Veins.—The common and superficial femoral veins, the accompanying vessels of the respective arteries, have the following arrangement: the common, formed by the union of the superficial and deep femoral, lies to the medial side of the common femoral artery and terminates at the superior border of Poupart's (*inguinal*) ligament in the external iliac vein. The vein, at its termination, with the medial of the two vertical septa of the femoral sheath, forms the lateral boundary of the femoral ring and femoral canal. Emptying into the common femoral are the long (*great*) saphenous and the deep external pudendal veins. Thrombosis of the common femoral vein, usually the left, is a complication of many infections.

The **superficial femoral vein,** like the artery, consists of a superficial and a deep portion. It is the continuation of the popliteal vein, and begins at the opening in the adductor magnus, through which it passes. The deep portion of the vein lies to the lateral side of the deep portion of the artery in the distal part of Hunter's (*adductor*) canal, and is rather firmly adherent to the artery in that situation; as it ascends it gradually passes behind the artery. The superficial portion of the vein lies behind the superficial femoral artery at the apex of Scarpa's (*femoral*) triangle, and passes to the medial side of the artery in its course upward. The vein may be double, or plexiform, in Hunter's (*adductor*) canal.

The **deep femoral (profunda femoris) vein** accompanies the deep femoral (*profunda femoris*) artery, lying anterior to that vessel. Its tributaries correspond to the branches of the artery. It joins the superficial femoral vein three and seven-tenths to five centimeters (one and one-half to two inches) below Poupart's (*inguinal*) ligament to form the common femoral vein.

The anterior crural (femoral) nerve.—Emerging from beneath Poupart's (*inguinal*) ligament about six millimeters (one-fourth of an inch) to the lateral side of the common femoral artery, in the depression between the psoas and iliacus muscles, is the anterior crural (*femoral*) nerve, the largest branch of the lumbar plexus, covered by the iliac fascia. It arises from the second, third, and fourth lumbar nerves, and runs through the psoas muscle. In psoas abscess it is left intact, although the muscle may be entirely destroyed by necrosis. In the groove between the psoas and iliacus muscles it divides into two portions: an anterior and a posterior portion. From the *anterior portion* of the nerve arise the muscular branches to the pectineus and sartorius—the middle (*intermediate*) cutaneous and internal (*medial*) cutaneous nerves, already described.

The *nerve to the pectineus* passes medialward behind the sheath of the common femoral vessels and pierces the iliac fascia to enter the muscle. The nerve to the sartorius muscle is a part of the middle (*intermediate*) cutaneous.

From the *posterior portion* of the anterior crural (*femoral*) nerve arise the long saphenous (*saphenous*) nerve and muscular and articular branches.

The *long saphenous (saphenous) nerve*, the longest branch of the anterior crural (*femoral*), passes distally and medialward, close to the lateral side of the superficial femoral artery, approaching this vessel where it is crossed by the sartorius muscle. At this point the nerve enters Hunter's (*adductor*) canal, lying at first to the lateral side of the artery, next in front of it, and then to its medial side. With the superficial branch of the anastomotica magna (*genu suprema*) artery, it leaves the canal by piercing the distal portion of the roof. It descends with the superficial branch of the anastomotica magna (*genu suprema*) beneath the sartorius to the medial side of the knee, where it lies between the tendons of the sartorius and gracilis, pierces the deep fascia, and then leaves the artery. It then accompanies the long (*great*) saphenous vein along the medial aspect of the leg. At about the middle of the thigh it gives off a branch which communicates with the obturator and the internal (*medial*) cutaneous nerves, to form the *subsartorial plexus* which is found along the medial border of the sartorius just distal to the middle of the thigh. It supplies the adjacent skin and fascia. Beneath the sartorius the long saphenous (*saphenous*) nerve gives off a large patellar branch which pierces the muscle and the overlying deep fascia, and runs distally along the medial side of the patella and over the ligamentum patellæ to supply

the integument. The patellar branch gives off a twig to the patellar plexus. The long saphenous (*saphenous*) nerve must not be confounded with the nerve to the vastus internus (*vastus medialis*) muscle, which lies to its lateral side.

The *muscular branches* supply all the muscles of the anterior part of the thigh, except the sartorius, which is supplied by the middle (*intermediate*) cutaneous, and the tensor fasciæ femoris (*tensor fasciæ latæ*), which is supplied by the superior gluteal. The branches to the rectus femoris muscle enter its under surface high up. One of them sends an articular branch to the hip-joint. The branch to the vastus internus (*vastus medialis*) muscle lies along the lateral side of the long saphenous (*saphenous*) nerve. The branch to the vastus externus (*vastus lateralis*) is accompanied by the descending branch of the external (*lateral*) circumflex artery. The nerve to the crureus (*vastus intermedius*) sends a branch to the proximal part of that muscle, runs downward between the crureus (*vastus intermedius*) and vastus internus (*vastus medialis*), and supplies the subcrureus (*articularis genu*) and the synovial membrane of the knee-joint.

The *articular branches* supply the hip-joint and knee-joint. The articular twigs to the hip-joint come from a nerve to the rectus femoris muscle. The articular twigs to the knee-joint come from the nerves to the vastus internus (*vastus medialis*) and vastus externus (*vastus lateralis*).

The **quadriceps extensor (quadriceps femoris) muscle** (Plate CCXCIV) occupies the front of the thigh and is situated between the tensor fasciæ femoris (*tensor fasciæ latæ*) and the ilio-tibial band on the lateral, and the adductors on the medial side. This muscle includes the rectus femoris and triceps femoris muscles, the latter comprising the vastus externus (*vastus lateralis*), the crureus (*vastus intermedius*), and the vastus internus (*vastus medialis*) muscles.

The **rectus femoris muscle** occupies the middle of the front of the thigh. It *arises* by two heads: the anterior, or short, head from the anterior inferior spine of the ilium; the posterior, long, or reflected head, from the lateral surface of the ilium above the acetabulum. The long, or reflected, head is attached to the capsule of the hip-joint. The two heads unite and the muscle then descends as a bipenniform fleshy mass along the front of the thigh. It is *inserted* through the common extensor tendon into the proximal border of the patella. It will therefore be seen that the rectus muscle is not attached to the femur, but passes over it from the ilium above, to the patella below. Note that the proximal part of the anterior, and the distal part of the posterior surface of the rectus muscle are aponeurotic. In front of the rectus are part of the gluteus minimus, the tensor fasciæ femoris (*tensor fasciæ latæ*), the sartorius, the iliacus, and the fascia lata.

It rests upon the capsule of the hip-joint, the external (*lateral*) circumflex vessels, and the crureus (*vastus intermedius*) and vasti muscles.

Nerve Supply.—From the posterior division of the anterior crural (*femoral*) nerve.

The **vastus externus** (**vastus lateralis**) **muscle** is the largest of the muscles forming the triceps femoris, and produces a prominence on the lateral aspect of the distal part of the thigh. It is covered by a dense aponeurosis, and *arises* from the proximal half of the anterior intertrochanteric line and the femur immediately distal to this point, from the anterior and lateral surface of the base of the greater trochanter, from the anterior margin of the gluteal ridge, from nearly the whole length of the lateral lip of the linea aspera, and to a slight extent from the lateral intermuscular septum near the linea aspera. The fibers pass downward and forward and terminate in an aponeurosis which is *inserted* into the proximal and lateral borders of the patella, forming a part of the common extensor tendon and becoming connected with the capsule of the knee-joint. It is covered by the iliotibial band of fascia lata, the fascia lata, the rectus femoris, the tensor fasciæ femoris (*tensor fasciæ latæ*), and the gluteus maximus. A bursa is interposed between this muscle and the gluteus maximus. It rests on the femur, the crureus (*vastus intermedius*) muscle, the descending branch of the external (*lateral*) circumflex artery, and the muscular branch of the anterior crural (*femoral*) nerve, which supplies it. This artery and nerve therefore lie between it and the crureus (*vastus intermedius*) muscle.

Nerve Supply.—Its nerve supply is derived from the anterior crural (*femoral*) nerve.

The **vastus internus** (**vastus medialis**) and the **crureus** (**vastus intermedius**) **muscles,** being continuous with each other, are best described as one muscle. Making an arbitrary division, that portion of the muscle lying beneath the rectus would be the crureus (*vastus intermedius*); and that to the medial side, the vastus internus (*vastus medialis*). Immediately above the patella and beneath the tendon of the rectus there is a narrow interval which marks the line of separation between the tendon of the vastus internus (*vastus medialis*) and that of the crureus (*vastus intermedius*). These muscles *arise* from the rough line leading from the lesser trochanter to the linea aspera, from the entire length of the medial lip of the linea aspera, from the medial condyloid ridge above the opening in the adductor magnus, from the medial intermuscular septum, from the anterior intertrochanteric line, and the proximal three-fourths of the anterior and lateral surface of the femur in front of, and distal to the attachment of the vastus externus (*vastus lateralis*). The fibers composing the vastus internus (*vastus medialis*) pass downward and forward, while those composing the crureus (*vastus*

intermedius) pass vertically downward. They are *inserted* by an aponeurosis into the proximal and medial borders of the patella to form part of the common extensor tendon. This aponeurosis, like that of the vastus externus (*vastus lateralis*) muscle, gives off a fibrous expansion to the capsular ligament of the knee-joint. The vastus internus (*vastus medialis*) forms the prominence in the distal part of the thigh above the medial side of the knee. The two muscles are covered by the sartorius, rectus femoris, and iliacus muscles, and the deep fascia, or fascia lata. They rest upon the femur, the subcrureus (*articularis genu*), and the synovial membrane of the knee-joint. The vastus internus (*vastus medialis*) muscle helps to form Hunter's (*adductor*) canal, the femoral vessels and the long saphenous (*saphenous*) nerve being in relation with the muscle in this part of the thigh.

Nerve Supply.—The crureus (*vastus intermedius*), in its proximal part, receives numerous branches from the posterior division of the anterior crural (*femoral*) nerve. The nerve to the vastus internus (*vastus medialis*) is a large branch from the anterior crural (*femoral*) that lies lateral to the femoral artery in the proximal part of Hunter's (*adductor*) canal.

The extensor tendon.—By the union of the tendons of the rectus, vastus externus (*vastus lateralis*), vastus internus (*vastus medialis*), and crureus (*vastus intermedius*) muscles a broad flat tendon is formed, the **common extensor tendon,** which is apparently *inserted* into the proximal border and sides of the patella. The common extensor tendon is in reality prolonged beyond the patella as a thick narrow tendon about five centimeters (two inches) in length, the **tendo patellæ,** or **ligamentum patellæ,** which passes in front of the knee-joint, and is *inserted* into the distal part of the tubercle (*tuberosity*) of the tibia. Between the tendo patellæ and the overlying integument in the superficial fascia is a synovial bursa, the *prepatellar bursa,* enlargement of which constitutes "housemaid's knee." Between the tendo patellæ and the proximal part of the tubercle (*tuberosity*) of the tibia is a second bursa, the *infrapatellar bursa,* while between the femur and the portion of the common extensor tendon formed by the tendon of the crureus (*vastus intermedius*) is a bursa of considerable size, the *suprapatellar bursa,* which, in the majority of adults, communicates with the synovial sac of the knee-joint. Under such circumstances, synovitis of the knee with distention of the synovial sac occasions a prominence immediately above the patella. The bursa probably develops independently of the capsule which then lies in front of its most distal part, the communication forming later. The communication may be absent in the infant. The communication may be so large that the cavity of the joint and bursa present no sign of subdivision. When the synovial membrane of the knee is very greatly distended, it may extend some distance above, and to

the sides of the patella, forcing its way beneath the surrounding muscles which in this situation are connected to the femur by loose connective tissue. The common extensor tendon, the expansions of the vasti muscles, the patella, the tendo patellæ, and the ilio-tibial band afford ample protection to the front and sides of the knee-joint, which are most exposed to injury.

The **subcrureus** (**articularis genu**) **muscle,** some of the distal fibers of the crureus (*vastus intermedius*), *arises* from the anterior surface of the distal part of the femur and is *inserted* into the synovial membrane of the knee-joint. When the muscle acts, it draws the proximal portion of the synovial membrane upward, preventing its being pinched in full extension of the joint.

Nerve Supply.—From the branch to the vastus internus (*vastus medialis*) muscle.

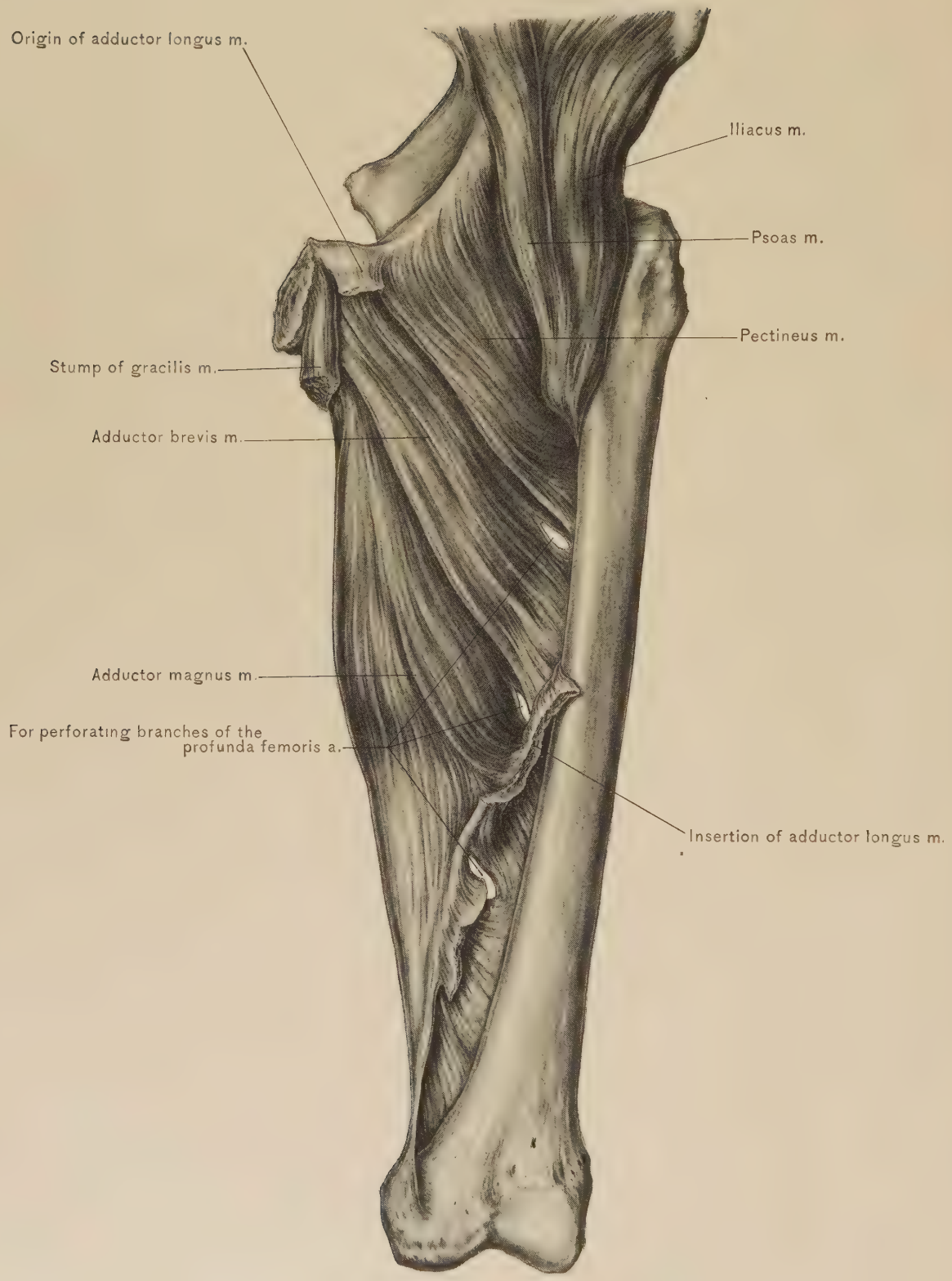
Action.—The action of the quadriceps extensor (*quadriceps femoris*) muscle, as its name indicates, is to extend the leg upon the thigh. The rectus muscle, in addition to being an extensor of the leg, is a flexor of the thigh upon the pelvis. When acting from its point of insertion, the rectus muscle flexes the pelvis on the thigh. The quadriceps extensor (*quadriceps femoris*) muscle is one of the most powerful muscles of the body. This is often demonstrated by its fracturing the patella transversely in the attempt to recover the erect position when falling. In this fracture the fibrous covering of the patella is also torn through. The resulting union is fibrous, if the fragments are not brought into direct apposition by the removal of any dangling fragments of the torn capsule. When fracture of the patella is the result of direct violence, the fibrous covering remains intact and the fracture is often comminuted. Violent contraction of the rectus, instead of fracturing the patella, may rupture a few of its own fibers and produce a severe sprain, or the muscle may be torn from the patella, or the ligamentum patellæ may be ruptured.

The **tensor fasciæ femoris** (**tensor fasciæ latæ**) is situated at the proximal third and on the lateral aspect of the thigh, between the gluteus medius and the sartorius. It *arises* from the anterior part of the lateral lip of the crest of the ilium, from the surface of the bone below the anterior superior spine, and from the fascia lata. It passes downward and slightly backward and is *inserted* into that portion of the fascia lata known as the ilio-tibial band, at the junction of the proximal with the middle third of the thigh. It is a medial rotator of the thigh, acting in conjunction with the anterior fibers of the gluteus medius. It also assists in fixing the pelvis upon the thigh.

Nerve Supply.—From a branch of the superior gluteal nerve.

Action.—It is a tensor of the fascia lata; by continuing its action it also abducts the thigh and rotates it medialward. When the body is erect, it steadies

PLATE CCXCVI.



ADDUCTOR MUSCLES.

the pelvis upon the femur, and by the ilio-tibial band it steadies the condyles of the femur on the tibia, by acting from below. It also assists the gluteus maximus muscle to support the knee in extension.

The ilio-psoas tendon.—The terminal portions of the iliacus and psoas magnus muscles, seen to the lateral side of the femoral vessels at the proximal part of the thigh, form the ilio-psoas tendon, which winds downward and backward over the capsular ligament of the hip-joint to be *inserted* into the lesser trochanter of the femur. Between the tendon and capsule is a bursa which often communicates with the joint. When this bursa is the seat of chronic inflammation, it may form a tumor of considerable size on the front of the thigh. Owing to the close proximity of the bursa to the bony pelvis, suppuration may lead to necrosis of the pelvis. When the bursa is inflamed, the thigh is flexed on the pelvis to relieve tension. This position of the limb, together with tenderness, pain, and swelling to the extent of obliterating the normal crease of the groin, may be mistaken for hip-joint disease, by the inexperienced observer.

Psoas abscess most commonly points to the lateral side of the femoral vessels, at the proximal part of the thigh, finding its way beneath the ilio-psoas fascia. Should the abscess pass downward to the point of insertion of the ilio-psoas tendon, it appears on the medial side of the thigh distal to the apex of Scarpa's (*femoral*) triangle.

Nerve Supply.—The psoas and iliacus muscles receive their nerve supply from the anterior crural (*femoral*).

Action of the Ilio-psoas.—The iliacus and psoas magnus muscles act as flexors, adductors, and medial rotators of the thigh. They are described with the abdomen and pelvis (Vol. III).

The **Adductor Muscles** (Plate CCXCVI), which include the pectineus, gracilis, adductor longus, adductor brevis, and adductor magnus, should next be studied. The obturator externus muscle also acts as an adductor, but it is chiefly a lateral rotator.

The **gracilis,** a long, flat muscle, and the most medial of the adductor group, *arises* by a broad thin tendon, five to seven centimeters (two to three inches) wide, from the medial margin of the body and ramus of the pubis. It is superficial throughout, and terminates in a round tendon which passes behind the medial condyle of the femur, over the internal lateral (*tibial collateral*) ligament of the knee-joint, and between the tendons of the semitendinosus and sartorius muscles, to be *inserted* into the proximal part of the medial aspect of the shaft of the tibia below the medial tuberosity (*medial condyle*). The tendon, as it passes over the internal lateral (*tibial collateral*) ligament, has beneath it a bursa which is common to it and the tendon of the semitendinosus. It is one of the medial

hamstring tendons. Between the tendons of the gracilis and the sartorius passes the long saphenous (*saphenous*) nerve.

Nerve Supply.—From the third and fourth lumbar, through the anterior branch of the obturator nerve.

Action.—The action of the gracilis is to adduct the thigh and flex the knee. When the knee is flexed, the gracilis assists in rotating the leg medialward.

The **adductor longus muscle,** more superficial than the adductors brevis and magnus, lies between the gracilis and pectineus at its point of origin, and *arises* by a short round tendon from the front of the body of the pubis below the crest, and in the angle between the crest and the symphysis. It becomes broader as it passes downward, laterward, and backward, and is *inserted* by a broad aponeurosis into the middle third of the medial lip of the linea aspera between the vastus internus (*vastus medialis*) and adductor magnus, and into the adjacent medial intermuscular septum. Behind it lie the adductor brevis, the adductor magnus, the deep femoral vessels, and the anterior branches of the obturator vessels and nerve. On its lateral side is the pectineus, and on its medial side, the gracilis. The adductor longus and sartorius form two sides of Scarpa's (*femoral*) triangle, already described.

Nerve Supply.—From the third and fourth lumbar, through the anterior branch of the obturator nerve.

Action.—The adductor longus aids in adducting and flexing the thigh; it also acts as a lateral rotator.

The Adductor Longus Muscle as a Landmark in Hernia.—The adductor longus muscle is superficial and arises from the front of the body of the pubis below the crest; the tendon of origin of the muscle, can, therefore, be distinctly felt subcutaneously when the thigh is strongly abducted. This is of use in locating the spine (*tubercle*) of the pubis in differentiating between an inguinal and a femoral hernia, the former being to the medial side while the latter is to the lateral side of the spine.

The **pectineus muscle** lies on the same horizontal plane as the adductor longus, but lateral to it. It is separated from the adductor longus muscle by a slight interval through which can be seen the adductor brevis and the anterior branch of the obturator nerve. It *arises* from the ilio-pectineal line between the spine (*tubercle*) of the pubis and the ilio-pectineal eminence, from the surface of the bone in front of it, and from the prolongation of Gimbernat's ligament (*ligamentum lacunare*), which is continuous with the fascia covering the muscle. It passes downward, lateralward, and backward, and is *inserted* into the femur behind the lesser trochanter and the rough line leading from the trochanter to the linea aspera. In front of it are the common, superficial, and deep femoral vessels

and the ilio-psoas tendon. Behind, it rests upon the capsular ligament of the hip-joint, the adductor brevis and obturator externus muscles, and the obturator vessels and nerve. On its lateral side is the psoas magnus, but separated from it by an interval through which passes the internal (*medial*) circumflex branch of the deep femoral artery; on its medial side is the adductor longus.

Nerve Supply.—From the second, third, and fourth lumbar, through the anterior crural (*femoral*), and from the third lumbar through the accessory obturator when that nerve is present; occasionally, also through a branch of the obturator nerve itself.

Action.—The pectineus muscle acts as a flexor and adductor of the thigh and slightly as a lateral rotator.

Dissection.—Cut the adductor longus and the pectineus across near their origin and reflect them. This dissection will expose the anterior surface of the capsular ligament of the hip-joint, the adductor brevis, obturator externus, and adductor magnus muscles, the terminal portion of the deep femoral vessels, and the anterior branch of the obturator nerve.

The accessory obturator nerve.—In cutting through the pectineus muscle, the accessory obturator nerve, if present, will be seen passing beneath the lateral border of the muscle. It is a branch of the lumbar plexus, arising either from the obturator nerve or by filaments from the third and fourth lumbar nerves. It passes over the horizontal ramus of the pubis beneath the pectineus muscle, where it divides into the following branches: an articular branch to the hip-joint; a muscular branch to the pectineus, and a communicating branch to the anterior branch of the obturator.

The **obturator artery** enters the thigh through the upper part of the obturator foramen beneath the obturator nerve, and divides into two branches: an anterior and posterior, which encircle the margin of the foramen under cover of the obturator externus muscle. It supplies the pectineus, gracilis, and adductor muscles and anastomoses with the internal (*medial*) circumflex and sciatic (*inferior gluteal*) arteries. The posterior (*acetabular*) branch sends a twig through the cotyloid (*acetabular*) notch which is distributed to the ligamentum teres and the head of the femur. A pubic branch ramifies on the pelvic surface of the pubis and anastomoses with its fellow of the opposite side and with the pubic branch of the deep (*inferior*) epigastric. This anastomosis may enlarge to form an **abnormal obturator,** replacing the normal obturator artery.

The **obturator nerve,** a branch of the lumbar plexus, arises from the second, third, and fourth lumbar nerves. It leaves the pelvis through the upper part of the obturator, or thyroid, foramen in company with the obturator vessels, but lying above them. It then divides into an anterior and a posterior branch. The

anterior branch descends in front of the obturator externus and adductor brevis muscles, and beneath the pectineus and adductor longus muscles. It emerges from between the adductor longus and brevis muscles and communicates with the internal (*medial*) cutaneous and long saphenous (*saphenous*) nerves to form the subsartorial plexus. From the anterior branch the following branches are derived: an articular, to the hip-joint; muscular, to the gracilis, adductor longus, pectineus, and sometimes to the adductor brevis muscles. The *posterior branch* pierces the obturator externus muscle and descends between the adductor brevis and adductor magnus. From the posterior branch the following branches are derived: an articular, to the hip-joint which enters the joint through the cotyloid (*acetabular*) notch; muscular, to the obturator externus, adductor brevis, and adductor magnus muscles, and an articular branch to the knee-joint. The *articular branch* to the knee-joint pierces the adductor magnus muscle and descends on the popliteal artery and pierces the posterior ligament of the joint. Through the medium of the obturator nerve, pain in hip-joint disease is sometimes referred to the knee.

The **adductor brevis muscle** *arises* from the anterior surface of the body of the pubis below the spine (*tubercle*) and the adductor longus, and from about two and a half centimeters (one inch) of the lateral surface of the descending ramus (*inferior ramus*) of the pubis between the gracilis and the obturator externus. It broadens as it passes downward, lateralward, and backward to be *inserted* into the rough line leading from the lesser trochanter to the linea aspera and into the proximal part of the linea aspera immediately behind the pectineus and the proximal part of the adductor longus. Anterior to it are the pectineus and adductor longus muscles, the deep femoral vessels, and the anterior branch of the obturator nerve. Behind, it lies on the obturator externus and the adductor magnus muscles, the posterior branches of the obturator vessels, the posterior division of the obturator nerve, and a branch of the internal (*medial*) circumflex artery. On its lateral side are the obturator externus muscle, the internal (*medial*) circumflex artery and the ilio-psoas tendon. On its medial side are the gracilis and adductor magnus muscles. The adductor brevis muscle lies between the anterior and posterior branches of the obturator nerve.

Nerve Supply.—The nerve supply is furnished by filaments from the anterior, and sometimes from the posterior branch of the obturator nerve.

Action.—The adductor brevis acts as an adductor, flexor, and a lateral rotator of the thigh.

Dissection.—Cut the adductor brevis across near its origin and reflect it, when the posterior branch of the obturator nerve and the adductor magnus muscle throughout its entire extent will be exposed.

The **adductor magnus muscle,** the largest of the adductors, has an extensive origin, from the lateral surface of the descending (*inferior*) ramus of the pubis, the descending (*inferior*) ramus of the ischium, and the tuberosity of the ischium. The fibers arising from the descending (*inferior*) ramus of the pubis take a horizontal course and are *inserted* into the distal part of the linea quadrata and into the medial part of the rough line leading from the greater trochanter to the linea aspera, medial to the gluteus maximus; those from the descending (*inferior*) ramus of the ischium take an oblique course downward and lateralward and are *inserted* into the whole length of the linea aspera and the proximal part of the medial condyloid (*medial epicondylic*) ridge of the femur, and into the distal portion of the medial intermuscular septum; those arising from the tuberosity of the ischium form the thickest portion of the muscle, and descend almost vertically to terminate in a round tendon which is crossed by the sartorius muscle at the distal third of the thigh, and is *inserted* into the adductor tubercle, at the base of the medial condyle of the femur. The adductor tubercle marks the level of the top of the lower epiphysis of the femur and also of the highest part of the trochlear surface. The tubercle is the landmark in locating the part of the femur divided in the operation of osteotomy for knock-knee, the bone being cut through twenty millimeters (three-fourths of an inch) above this point. At the junction of the middle with the distal third of the thigh behind the medial condyloid (*medial epicondylic*) ridge, the fibers of the portion of the muscle arising from the descending (*inferior*) ramus of the ischium are inserted into a tendinous arch bridging over an opening, the *hiatus tendineus*, which gives passage to the superficial femoral vessels. This opening is the termination of Hunter's (*adductor*) canal. It is bounded anterolaterally by the femur, and posteromedially by the tendinous arch. Near its insertion into the linea aspera the muscle is pierced by the four perforating arteries and the articular branch of the obturator nerve which supplies the knee-joint. The portion of the muscle inserted into the entire length of the linea aspera and the internal condyloid (*medial epicondylic*) ridge forms a partition which separates the other muscles on the anterior and medial aspect of the thigh from the muscles on the posterior aspect. This partition will be seen to the best advantage after dissecting the back of the thigh. In front of the adductor magnus are the pectineus, the adductors brevis and longus, and the vastus internus (*vastus medialis*) muscle, the obturator nerve and artery, and the superficial and deep femoral vessels; above it are the internal (*medial*) circumflex artery and the obturator externus and quadratus femoris muscles; behind it are the biceps femoris, the semitendinosus and semimembranosus muscles, the great sciatic (*sciatic*) nerve, and the gluteus maximus muscle, and to the medial side are the gracilis and part of the sartorius muscles.

The proximal part of the pubic portion of this muscle is sometimes described as a separate muscle and called the **adductor minimus.**

Nerve Supply.—From the posterior branch of the obturator nerve which passes to the anterior surface of the muscle, and from branches of the great sciatic (*sciatic*) nerve which enter the posterior surface of the muscle.

Action.—The adductor magnus is the strongest of the adductors. The portion of the muscle arising from the tuberosity of the ischium rotates the thigh medialward as well, while the remainder of the muscle rotates the thigh lateralward. The ischial portion extends the thigh, while the pubic portion flexes it.

The action of the pectineus, gracilis, and adductor muscles is to adduct the thigh and rotate it lateralward. Taking their fixed point from below, they serve both to maintain the body in the erect posture and to flex the pelvis upon the femur. The pectineus and the adductors brevis, magnus, and longus are partial flexors of the thigh, acting in conjunction with the psoas and iliacus muscles. The adductor group of muscles is supplied by the obturator nerve. The pectineus muscle receives additional filaments from the accessory obturator and anterior crural (*femoral*) nerves, and the adductor magnus muscle from the great sciatic (*sciatic*) nerve.

Injuries of the adductors.—The adductor muscles, especially the adductor longus, are frequently sprained, or even partially ruptured, when riding horseback, producing "rider's sprain," the grip on the saddle being for the most part maintained by the adductor muscles. When the fibers of the adductor longus are ruptured, hemorrhage occurs, and the blood, if not rapidly absorbed, forms a clot; the clot, undergoing organization and ossification, forms a hard mass which has been mistaken for a detached piece of the pubis. When the tendon of the adductor longus is partially ossified, it constitutes "rider's bone."

Contraction of the adductors.—The tendon of the adductor longus may be very prominent, as a result of hip-joint disease or of disease of the cerebrum, as in Little's disease. When spastic paraplegia exists all of the adductors may be affected in varying degrees. The Förster operation of dividing the posterior nerve roots, the Stöffel operation of partial division of the obturator nerve and the infiltration of the nerve with alcohol are slowly being discarded, nor does the Royle operation of lumbar ramisection of the sympathetics hold out much hope in these cases. I believe that a carefully planned tenotomy will give the largest measure of success when associated with postoperative muscular re-education.

The **obturator externus muscle,** only the origin of which is seen in this dissection, *arises* from the lateral surface of the body and the descending (*inferior*) ramus of the pubis, the ascending (*superior*) ramus of the ischium, the medial

half of the lateral surface of the obturator membrane, and the tendinous arch over the obturator vessels. The muscle is more fully described with the gluteal region.

Obturator hernia.—The anatomy of obturator hernia, which takes place through the obturator foramen between the horizontal ramus of the pubis and the proximal portion of the obturator externus muscle, is important. The hernial protrusion lies lateral to the adductor longus muscle and beneath the pectineus muscle, to the medial side of the capsule of the hip-joint, and to the medial side of, and behind the femoral vessels. Pressure of the hernia upon the obturator nerve causes pain referred to the area of distribution of that nerve. Movement of the hip also excites pain. The position which the obturator vessels hold to the hernia varies; sometimes they are in front of, and at other times on the right or left side of the hernia. The incision to expose the hernia should be carried over the most prominent part of the tumor, dividing the skin and the superficial and deep fascia, care being taken to avoid wounding the internal saphenous (*great saphenous*) and common femoral veins. The pectineus muscle will then be exposed, at the medial border of which, and in the interval between it and the adductor longus, the sac can be reached. It may be necessary to displace the adductor brevis downward and medialward to facilitate exposure of the sac. Treves mentions a case (reported by Wood) in which a hernia of the adductor longus muscle through a rent in its aponeurosis was mistaken for an obturator hernia.

THE FRONT OF THE LEG AND THE DORSUM OF THE FOOT

Dissection.—Before removing the skin from the anterior surface of the leg and the dorsum of the foot, the foot should be extended and held in place by hooks. Continue the incision made on the medial side of the thigh down the medial side of the leg, over the medial malleolus, along the medial border of the foot to the base of the great toe. From this incision carry a transverse incision over the ankle and another across the dorsum of the foot at the base of the toes. Reflect the skin of the front of the leg and dorsum of the foot lateralward to expose the superficial fascia. The superficial fascia of the leg and foot is continuous with that of the thigh; the superficial vessels and nerves run in this fascia. These vessels and nerves are: the venous arch on the dorsum of the foot and the internal (*great*) and short (*small*) saphenous veins; the internal, or long, saphenous (*saphenous*), external, or short, saphenous (*sural*), and musculo-cutaneous (*superficial peroneal*) nerves, a small branch from the external popliteal (*common peroneal*) nerve and the internal terminal branch of the anterior tibial (*deep peroneal*) nerve. On the medial side of the foot and leg will be found the internal (*great*) saphenous vein, and on the lateral side of the foot the short (*small*) saphenous vein. These veins should be traced through the fascia before it is

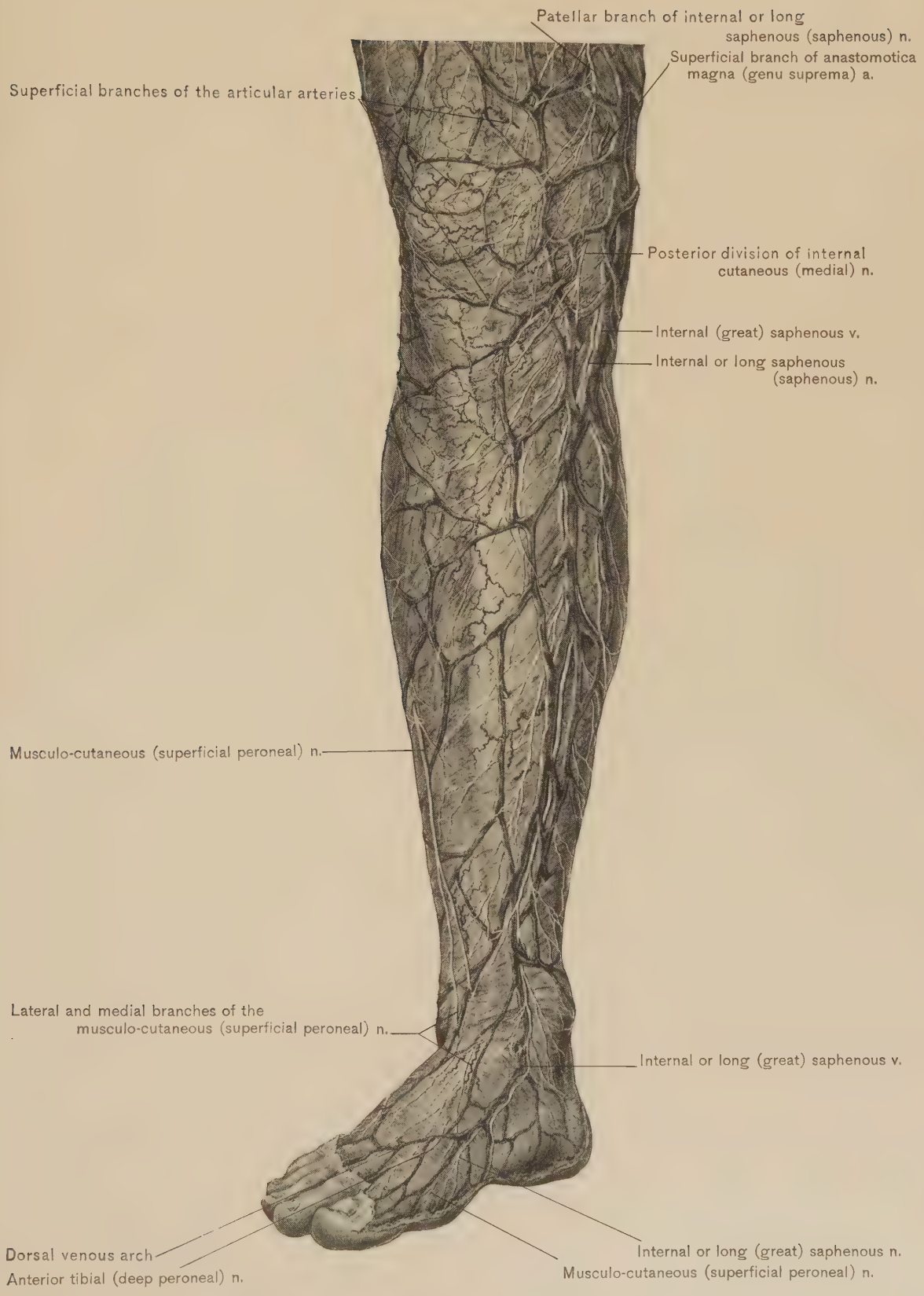
removed, when they will be seen to originate in a venous arch on the dorsum of the foot. The venous arch, with its convexity downward, extends across the instep. It receives the veins from the toes. The internal (*great*) saphenous vein begins at the medial end of the arch, passes upward in front of the medial malleolus, thence medially along the leg, a short distance posterior to the medial border of the tibia and behind the medial condyle, to become an occupant of the thigh. The external (*small*) saphenous vein arises from the lateral side of the arch, passes upward behind the lateral malleolus, to the lateral side of the tendo Achillis, along the back of the calf of the leg and between the heads of the gastrocnemius to pierce the deep fascia at the distal end of the popliteal space (*popliteal fossa*). It empties into the popliteal vein. These veins are accompanied throughout their course distal to the knee by the nerves of the same name. The superficial lymphatics of the leg, beginning in a plexus on the dorsum of the foot, gradually unite into larger trunks which accompany the internal (*great*) saphenous vein. The short (*small*) saphenous vein is also accompanied by lymphatics which come from the lateral border of the foot and the posterior aspect of the leg, and enter the popliteal glands.

The **internal,** or **long, saphenous** (**saphenous**) **nerve** (Plate CCXCVII), a branch of the anterior crural (*femoral*), becomes superficial soon after passing between the tendons of the sartorius and gracilis muscles. It passes down the medial side of the leg in close relation to the internal (*great*) saphenous vein. It divides into two branches, one of which passes to the medial side of the ankle and the other in front of the medial malleolus, to be distributed to the medial side of the foot as far as the ball of the great toe. It sends off twigs to the skin in its course. This nerve is frequently injured in dissections of the leg for varicose veins, with a resulting loss of sensation in its distribution.

The **external,** or **short, saphenous** (**sural**) **nerve** in this stage of the dissection is seen emerging from behind the lateral malleolus and running along the lateral side of the foot to the lateral side of the little toe.

The remaining superficial nerves seen in this dissection are the musculocutaneous (*superficial peroneal*), the medial terminal branch of the anterior tibial (*deep peroneal*), and branches of the external popliteal (*common peroneal*). The **branch from the external popliteal** (**common peroneal**) **nerve** supplies the skin over the proximal part of the leg. The **musculo-cutaneous** (**superficial peroneal**) **nerve** pierces the deep fascia at the junction of the intermediate and distal thirds of the leg as two branches, a medial and a lateral. The *medial branch* passes distally to the dorsum of the foot; it divides into two terminal branches, one of which supplies the medial side of the great toe, and the other the adjacent sides of the second and third toes. It also gives off branches which communicate with

PLATE CCXCVII.


Patellar branch of internal or long saphenous (saphenous) n.
Superficial branch of anastomotica magna (genu suprema) a.
Superficial branches of the articular arteries
Posterior division of internal cutaneous (medial) n.
Internal (great) saphenous v.
Internal or long saphenous (saphenous) n.
Musculo-cutaneous (superficial peroneal) n.
Lateral and medial branches of the musculo-cutaneous (superficial peroneal) n.
Internal or long (great) saphenous v.
Dorsal venous arch
Anterior tibial (deep peroneal) n.
Internal or long (great) saphenous n.
Musculo-cutaneous (superficial peroneal) n.

CUTANEOUS VESSELS AND NERVES OF FRONT OF LEG.

the **medial terminal branch of the anterior tibial** (**deep peroneal**) **nerve** and the nerve to the adjacent sides of the third and fourth toes. A small branch supplies the medial side of the ankle and foot and communicates with the long saphenous (*saphenous*). The *lateral branch* passes distally to the dorsum of the foot; it divides into three branches, one of which is joined by a filament from the medial branch and supplies the adjacent sides of the third and fourth toes; another supplies the adjacent sides of the fourth and fifth toes, and the remaining branch supplies the lateral side of the foot and communicates with the short saphenous (*sural*) nerve.

Dissection.—The superficial fascia is reflected by making incisions similar to those made in reflecting the skin. The superficial nerves should be traced while removing this fascia. The deep fascia will now be exposed.

The **deep,** or **crural, fascia** forms a continuous layer around the leg and foot, except over the subcutaneous surface of the tibia, where it blends with the periosteum. Proximally, it is attached to the head of the tibia, and to the fibula and patella, and is strengthened by expansions from the tendons of the sartorius, gracilis, semitendinosus, and biceps femoris muscles; it is also attached to the crest of the tibia. At the ankle, it is thickened and forms ligamentous bands which hold the tendons in position and assist in binding together the bones to which they are attached—the anterior annular (*transverse cruris and cruciatum cruris*), internal annular (*ligamentum laciniatum*), and external annular (*peroneal retinacula*) ligaments. Beneath these pass the extensor and flexor tendons, the anterior and posterior tibial vessels, and the anterior tibial (*deep peroneal*) and posterior tibial (*tibial*) nerves. From the under surface of the fascia of the front of the leg muscle fibers arise, particularly just below the knee, where it is impossible to remove the fascia without removing some of the muscle fibers. From the deep surface of the fascia two intermuscular septa pass medialward to be attached, one to the anterior (*anterior intermuscular septum*), and the other to the lateral (*posterior intermuscular septum*) border of the fibula. The anterior septum separates the extensor digitorum longus and peroneus tertius anteriorly from the peroneus longus and brevis posteriorly. The posterior septum separates the peronei, anteriorly, from the soleus and flexor hallucis longus, posteriorly. In the proximal third of the leg there is an additional intermuscular septum which separates the tibialis anterior and the extensor digitorum longus muscles. This septum is an important guide in the operation for ligation of the proximal part of the anterior tibial artery. In this operation the dissection is made on the tibial side of this septum. In the back of the leg there is a septum or transverse layer of fascia which separates the soleus muscle from the flexor digitorum longus, flexor hallucis longus, and tibialis posterior muscles.

The **anterior annular ligament** (**ligamenta transversum cruris and cruciatum cruris**) extends across the front of the ankle-joint and binds down the extensor tendons of the ankle and toes. It consists of two portions, a proximal and a distal. The *proximal portion* (*ligamentum transversum cruris*) is a strong, broad band attached laterally to the distal end of the fibula, medially to the tibia, and above is continuous with the deep fascia of the leg. The distal portion (*ligamentum cruciatum cruris*) is attached laterally to the os calcis(*calcaneus*) and the cuboid; medially, it divides into two portions, the proximal of which is attached to the medial malleolus and the distal to the scaphoid (*navicular*) and the internal (*first*) cuneiform bones, and plantar fascia. The proximal portion of the ligament has two separate compartments. The medial compartment contains the tibialis anterior; the lateral, the extensor digitorum longus and the peroneus tertius muscles. The distal portion of the ligament has three compartments: the medial contains the tendon of the tibialis anterior muscle; the intermediate, the tendon of the extensor hallucis longus muscle, and the lateral, the tendons of the extensor digitorum longus and peroneus tertius muscles. As these tendons pass under the distal band of the annular ligament, they are surrounded by synovial sheaths; hence tenosynovitis may occur here just as well as on the dorsal surface of the wrist. The tibialis anterior alone has a mucus sheath at the level of the proximal band. The anterior tibial vessels and anterior tibial (*deep peroneal*) nerve, without possessing distinct sheaths, pass beneath both portions of the anterior annular ligament, while the internal (*great*) saphenous vein and(*saphenous*) nerve and the musculo-cutaneous (*superficial peroneal*) nerve pass over it.

The **internal annular ligament** (**ligamentum laciniatum**) is a dense band of fibers which extends from the medial malleolus to the os calcis (*calcaneus*), where it becomes continuous with the plantar fascia and the tendinous portion of the abductor hallucis. It is continuous above with the deep fascia of the leg and the transverse layer of fascia beneath the soleus. It binds down the flexor tendons of the foot and toes and forms three canals, through which these tendons pass, each canal being lined by a separate synovial sheath. These canals transmit (in the following order, from medialward lateralward): the tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles. Beneath the ligament and between the tendons of the flexor digitorum longus and flexor hallucis longus pass the posterior tibial vessels and posterior tibial (*tibial*) nerve; so that the order of the tendons, vessels, and nerve beneath the ligament, from medialward lateralward, is: the tendons of the tibialis posterior and flexor digitorum longus muscles; the posterior tibial artery and veins, the posterior tibial (*tibial*) nerve, and the flexor hallicus longus tendon.

The **external annular ligament** (**peroneal retinacula**) extends from the lateral malleolus to the os calcis (*calcaneus*). It confines the tendons of the peroneus longus and brevis muscles. It is divided into a proximal and distal portion. The proximal portion holds the muscles against the posterior surface of the lateral malleolus and is lined with a single sheath, while the distal portion binds them to the lateral surface of the os calcis (*calcaneus*) and is lined with a separate sheath for each muscle.

Inflammation under the crural fascia.—Owing to the density of the deep fascia of the leg, sloughing or gangrene develops early in inflammation of this part attended by excessive effusion, or in cases of great extravasation of blood following a wound of one of the deep vessels. A collection of pus beneath the deep fascia, if not evacuated early, will burrow extensively.

Dissection.—Remove the deep fascia as far down as the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*), making an incision through it along the lateral border of the subcutaneous surface of the tibia. In taking off this fascia be careful to remove as little as possible of the muscle fiber, and not to cut the musculo-cutaneous (*superficial peroneal*) nerve, which pierces it on the lateral aspect of the leg, at the junction of the intermediate with the distal third. This will expose the muscles on the anterior and lateral side of the leg: the tibialis anterior, extensor digitorum longus, extensor hallicus longus, peroneus tertius, peroneus longus and brevis.

The **tibialis anterior muscle** is situated immediately to the lateral side of the tibia. It *arises* from the lateral tuberosity (*lateral condyle*) and proximal two-thirds of the lateral surface of the shaft of the tibia, from the interosseous membrane, from the deep fascia covering the muscle, and from the intermuscular septum between it and the extensor digitorium longus muscle. At the distal third of the leg the fibers terminate in a flat tendon which passes obliquely over the front of the ankle through the most medial compartment of the anterior annular ligament, to the medial side of the foot, where it is *inserted* into the internal (*first*) cuneiform and the base of the metatarsal bone of the great toe. The tibialis anterior muscle lies at first to the lateral side of the tibia. It rests, from above downward, on the interosseous membrane, the distal end of the tibia, the ankle-joint, and the scaphoid (*navicular*) bone. To its lateral side are the anterior tibial vessels and anterior tibial (*deep peroneal*) nerve and the extensor digitorum longus and extensor hallucis longus muscles. The anterior tibial vessels and anterior tibial (*deep peroneal*) nerve are concealed by the muscles in the proximal part of the leg.

Nerve Supply.—Its nerve supply is derived from the anterior tibial (*deep peroneal*) nerve.

Action.—It draws the foot upward (dorsi-flexion) and medialward and slightly inverts the sole. Its contraction favors the deformity known as talipes varus.

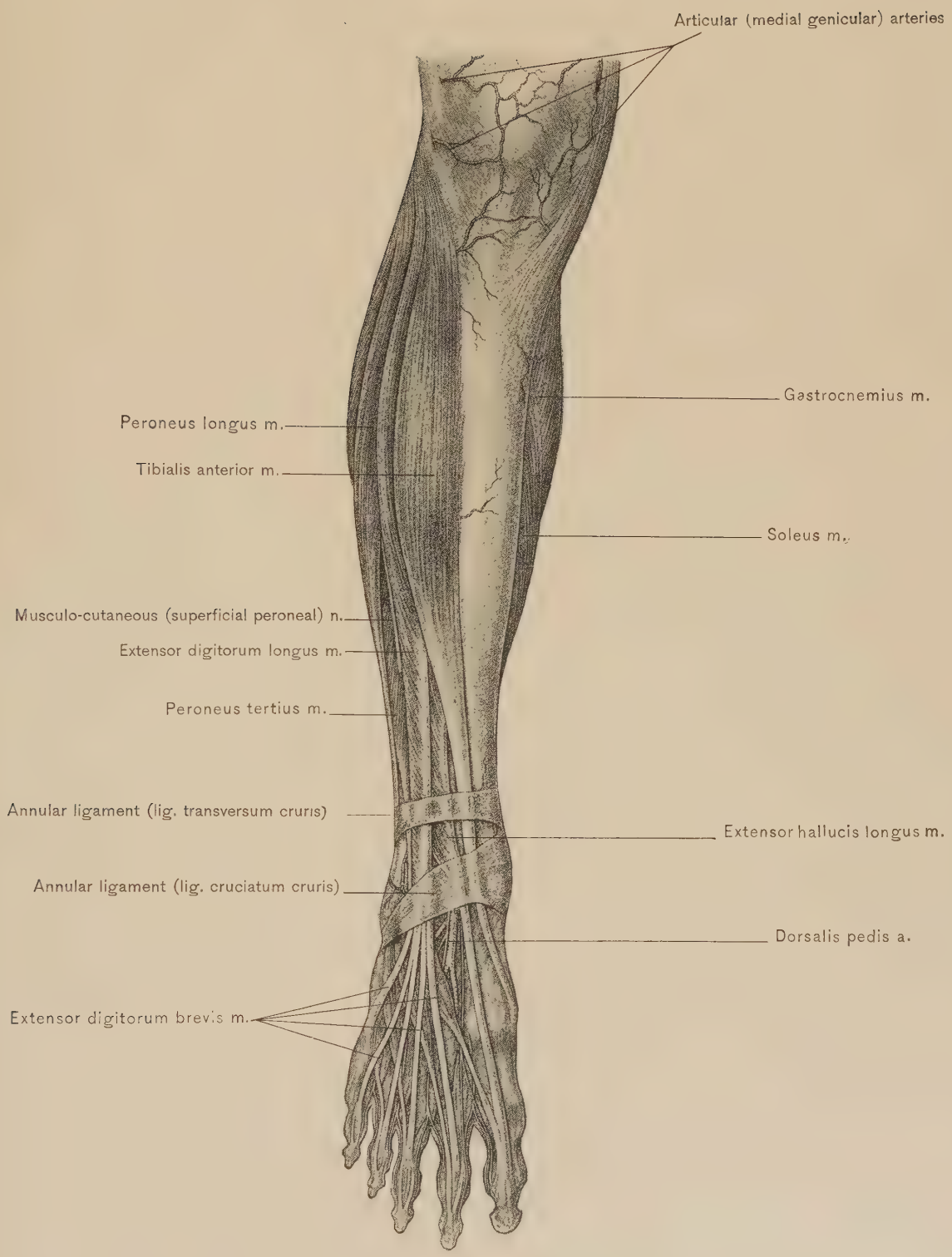
The **extensor digitorum longus muscle** (Plate CCXCVIII) lies to the fibular side of the tibialis anterior. It *arises* from the lateral tuberosity (*lateral condyle*) of the tibia, from the proximal three-fourths of the shaft of the fibula, from the interosseous membrane, from the deep fascia, and from the intermuscular septa separating it from the tibialis anterior on the medial, and the peronei muscles on the lateral side. Its fibers terminate in a tendon which passes in front of the ankle through the lateral compartment of both portions of the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*), and divides into four slips. Below the ligament these slips are continued to the four lesser toes and are *inserted* into the bases of the second and third phalanges. Each tendon, opposite the metatarso-phalangeal joint, is joined laterally by the tendon of the extensor digitorum brevis and by a fibrous expansion from the interossei and lumbricales to form an aponeurosis which covers the dorsal surface of the proximal phalanx. This aponeurosis gives off processes to the lateral ligaments of the metatarso-phalangeal joints and divides into three slips opposite the joint between the proximal and second phalanges: the intermediate slip is inserted into the base of the second phalanx, while the two collateral slips unite on the dorsal surface of the second phalanx and are continued forward to be *inserted* into the base of the distal phalanx. The arrangement of the extensor tendons of the toes is similar to that of the fingers. The extensor digitorum longus lies between the tibialis anterior and the peroneus longus. The anterior tibial vessels and anterior tibial (*deep peroneal*) nerve and the extensor hallucis longus and tibialis anterior muscles are medial to it, and the peronei muscles and the musculo-cutaneous (*superficial peroneal*) nerve lateral to it. It lies on the fibula, the interosseous membrane, and the ankle-joint. Its tendons rest on the extensor digitorum brevis muscle and on the tarsus and metatarsus. The most medial tendon of the extensor digitorum longus muscle is a guide in the ligation of the dorsalis pedis artery.

Nerve Supply.—From the anterior tibial (*deep peroneal*) nerve.

Action.—The muscle is an extensor of the four lateral toes and a dorsi-flexor of the ankle-joint.

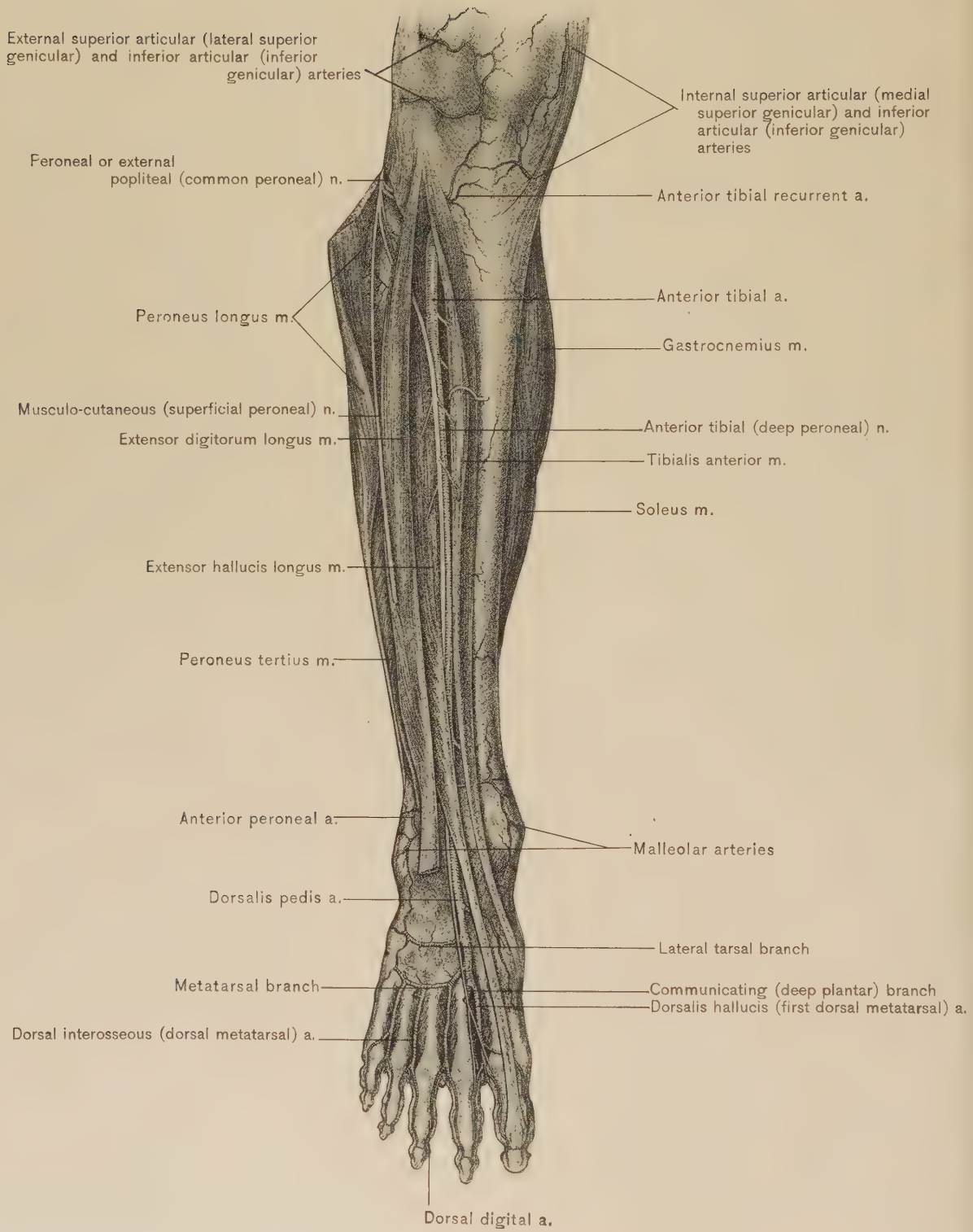
The **peroneus tertius** is a small muscle and may be considered a part of the extensor digitorum longus. It *arises* from the distal fourth of the anterior surface of the shaft of the fibula, from the interosseous membrane and from the intermuscular septum between it and the peroneus brevis. Its tendon passes through the same canal in the annular ligament as the extensor digitorum longus

PLATE CCXCVIII.



EXTENSORS OF DIGITS. PERONEAL MUSCLES.

PLATE CCXCIX.


External superior articular (lateral superior genicular) and inferior articular (inferior genicular) arteries
Internal superior articular (medial superior genicular) and inferior articular (inferior genicular) arteries
Peroneal or external popliteal (common peroneal) n.
Anterior tibial recurrent a.
Anterior tibial a.
Peroneus longus m.
Gastrocnemius m.
Musculo-cutaneous (superficial peroneal) n.
Anterior tibial (deep peroneal) n.
Extensor digitorum longus m.
Tibialis anterior m.
Soleus m.
Extensor hallucis longus m.
Peroneus tertius m.
Anterior peroneal a.
Malleolar arteries
Dorsalis pedis a.
Lateral tarsal branch
Metatarsal branch
Communicating (deep plantar) branch
Dorsalis hallucis (first dorsal metatarsal) a.
Dorsal interosseous (dorsal metatarsal) a.
Dorsal digital a.

ANTERIOR TIBIAL ARTERY, ANTERIOR TIBIAL (DEEP PERONEAL) NERVE, DORSALIS PEDIS ARTERY AND MUSCULO-CUTANEOUS (SUPERFICIAL PERONEAL) NERVE.

and is *inserted* into the medial side of the dorsal surface of the base of the fifth metatarsal

NERVE SUPPLY.—From the anterior tibial (*deep peroneal*) nerve.

ACTION.—It draws the lateral border of the foot upward, everting the sole, and assists the tibialis anterior and extensor digitorum longus in dorsi-flexing the ankle.

The **extensor hallucis longus muscle** at its origin is deep seated between the tibialis anterior and the extensor digitorum longus. At the distal portion of the leg it becomes superficial. It *arises* from the anterior surface of the intermediate two-fourths of the shaft of the fibula and the interosseous membrane. Its fibers terminate in a tendon which passes beneath the proximal portion of the anterior annular (*transversum cruris*) ligament over the ankle and through the middle compartment of the distal portion (*cruciatum cruris*) of the ligament between the tendons of the tibialis anterior and the extensor digitorum longus. Thence it passes along the dorsum of the foot to be *inserted* into the base of the distal phalanx of the great toe. Opposite the metatarso-phalangeal joint a small slip from either side of the tendon is attached to the lateral ligament and the sides of the base of the proximal phalanx. Above the ankle the tendon crosses the anterior tibial vessels and anterior tibial (*deep peroneal*) nerve to the medial side. To the medial side of this muscle in the leg are the tibialis anterior muscle and the anterior tibial vessels and anterior tibial (*deep peroneal*) nerve; to its lateral side, above, is the extensor digitorum longus muscle, and below, near the ankle, are the anterior tibial vessels and nerve (*deep peroneal nerve*). It rests on the interosseous membrane, the tibia, and the anterior tibial vessels and anterior tibial (*deep peroneal*) nerve. On the dorsum of the foot, to the medial side of its tendon, is the tendon of the tibialis anterior, to the lateral side are the dorsalis pedis vessels and anterior tibial (*deep peroneal*) nerve and the most medial tendon of the extensor digitorum brevis.

NERVE SUPPLY.—From the anterior tibial (*deep peroneal*) nerve.

ACTION.—It extends the great toe, assists in dorsi-flexing the foot, and assists in inverting the sole of the foot.

The anterior tibial group of muscles is often paralyzed as the result of anterior poliomyelitis in children. The foot in such circumstances cannot be flexed on the leg, and assumes the extended position, and "foot drop" occurs; the muscles become markedly atrophied. From the contracture of the calf muscles, talipes equinus may follow. The muscles may also be paralyzed from injury to the anterior tibial (*deep peroneal*) nerve as it winds around the head of the fibula.

The **anterior tibial artery** (Plate CCXCIX), the smaller of the two terminal branches of the popliteal, reaches the front of the leg about four centimeters (an

inch and a quarter) below the head of the fibula by passing between the two heads of the tibialis posterior muscle and above the proximal border of the interosseous membrane. It then descends, in the proximal two-thirds of its course lying upon the interosseous membrane, and lower down along the front of the tibia. It passes in front of the ankle beneath the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*), at the lower border of which it becomes the dorsalis pedis. A line drawn from a point midway between the head of the fibula and the tubercle (*tuberosity*) of the tibia to a point midway between the two malleoli in front will indicate the course of this artery.

Relations of the Anterior Tibial Artery.—In the proximal third of the leg it lies between the tibialis anterior and the extensor digitorum longus muscles; in the middle third, between the tibialis anterior and the extensor hallucis longus muscles; in the distal third and in front of the ankle, it is crossed by the tendon of the extensor hallucis longus muscle and lies between it and the extensor digitorum longus tendon. It is accompanied by two veins, the venæ comites, and by the anterior tibial (*deep peroneal*) nerve. At the proximal third of the leg the nerve lies lateral to the artery; in the intermediate third, in front of the artery, and at the distal third, again to the lateral side of the artery. Ligation of the anterior tibial is more difficult in the proximal third than in either the intermediate or the distal third of the leg, owing to the distance it lies from the surface.

Injuries of the anterior tibial artery.—In fracture of both bones of the leg, or of the tibia alone, either the anterior tibial or the posterior tibial artery may be injured. A periosteal growth, most commonly sarcoma, involving either of the bones of the leg, may also include the anterior tibial artery, and in such circumstances the vessel would be liable to injury should the growth be excised. The closer to the interosseous membrane the anterior tibial artery is cut, the more difficult it is to ligate it. Hemorrhage from a stab wound of the front of the leg does not necessarily mean that the anterior tibial has been cut. The weapon may have passed between the bones through the interosseous membrane and have wounded a vessel behind the latter structure.

The branches of the anterior tibial artery are, from above downward: the posterior tibial recurrent, superior fibular, anterior tibial recurrent, muscular, and medial and lateral malleolar.

The *posterior tibial recurrent artery* is an inconstant branch. When present, it arises from the anterior tibial artery on the back of the leg and ascends beneath the popliteus muscle to the back of the knee-joint. It supplies the popliteus, the knee, and the superior tibio-fibular joints, and anastomoses with the inferior articular (*inferior genicular*) branches of the popliteal.

The *superior fibular branch* arises from the anterior tibial, sometimes from the posterior tibial, passes through the lateral head of the soleus muscle, winds around the neck of the fibula, and terminates in the peroneus longus muscle.

The *anterior tibial recurrent artery* arises from the anterior tibial immediately after it has reached the anterior part of the leg; it ascends through the tibialis anterior muscle to the front of the knee-joint, and anastomoses with the articular (*genicular*) branches of the popliteal, and with the anastomotica magna (*genu suprema*) branch of the femoral artery.

The *muscular branches* are distributed to the muscles on either side of the artery. Some pierce the deep fascia and supply the integument. Others pierce the interosseous membrane, and, after reaching the posterior part of the leg, anastomose with branches of the posterior tibial and peroneal arteries.

The *two malleolar arteries* arise from the anterior tibial above the ankle-joint. The *medial malleolar artery* arises about five centimeters (two inches) above the ankle and passes downward and medialward beneath the tendons of the extensor hallucis longus and tibialis anterior muscles to the medial malleolus, at the distal margin of which it divides into branches that anastomose with the medial plantar artery and the medial calcanean branch of the posterior tibial artery. The *lateral malleolar artery*, the larger of the two, arises lower than the medial, passes downward and lateralward beneath the tendons of the extensor digitorum longus and peroneus tertius muscles, to reach the anterior part of the lateral malleolus, where it anastomoses with the anterior peroneal artery (*perforating branch*), and the tarsal (*lateral tarsal*) branch of the dorsalis pedis artery.

In addition to the above-named branches, small articular twigs arise from the anterior tibial artery at the ankle, to supply the ankle-joint.

The **anterior peroneal artery** (**perforating branch**) arises from the peroneal and pierces the interosseous membrane about five centimeters (two inches) above the lateral malleolus. It emerges from under the peroneus tertius muscle and passes over the lateral malleous and the lateral side of the tarsus. It anastomoses with the lateral malleolar and tarsal arteries.

The Peroneus Longus and Brevis Muscles.—Upon the lateral side of the leg, separated from the muscles upon the anterior part by a strong intermuscular septum of the deep fascia, are the peroneus longus and peroneus brevis muscles.

The **peroneus longus,** the more superficial, is situated at the proximal part of the lateral aspect of the leg. It *arises* from the head and the lateral surface of the proximal two-thirds of the shaft of the fibula, from the lateral tuberosity (*lateral condyle*) of the tibia, from the deep fascia which covers it, and from the intermuscular septa between it and the muscles on the front, and on the back of

the leg. The fibers terminate in a long tendon which passes beneath the external annular ligament (*peroneal retinacula*) behind the lateral malleolus, in a groove common to it and the peroneus brevis. It then passes along the lateral side of the os calcis (*calcaneus*), surrounded by a separate fibrous sheath. After reaching the lateral side of the cuboid it turns into the sole of the foot, across which it runs in a groove on the under surface of the cuboid. This groove is converted into a canal by the long calcaneo-cuboid ligament. The tendon is *inserted* into the lateral side of the base of the first metatarsal bone, and the internal (*first*) cuneiform. Where the tendon rests against the lateral side of the cuboid it often contains a sesamoid bone or cartilage. The tendons of the peroneus longus and peroneus brevis possess a common synovial sheath behind the lateral malleolus which divides to envelop the tendons separately on the lateral side of the calcaneus. The tendon of the peroneus longus has another synovial sheath in the dorsum of the foot. In the operation for removal of the metatarsal bone of the great toe, when possible the attachment of the tendon of the peroneus longus muscle should be left undisturbed. Between the peroneus longus and the neck of the fibula is the peroneal (*common peroneal*), or external politeal, nerve. It is apt to be injured here in contusion of the proximal lateral portion of the leg, and it may be divided in incised or lacerated wounds in this region. Running through its substance, and between it and the peroneus brevis, is the musculo-cutaneous (*superficial peroneal*) nerve. The peroneus longus muscle lies between two strong intermuscular septa which separate it from the extensors anteriorly and the flexors posteriorly.

The **peroneus brevis muscle** lies deep to the peroneus longus and anterior to it, and is smaller than the latter. It *arises* from the distal two-thirds of the lateral surface of the shaft of the fibula, in front of the peroneus longus, and from the intermuscular septa between it and the muscles on the front and back of the leg. Its fibers terminate in a tendon which passes beneath the external annular ligament (*peroneal retinacula*) and through the groove behind the lateral malleolus common to it and the peroneus longus, in this situation lying in front of the tendon of the peroneus longus. It then passes along the lateral side of the os calcis (*calcaneus*) above the tendon of the peroneus longus muscle in a separate sheath, and is *inserted* into the lateral side of the tuberosity on the base of the fifth metatarsal bone. In the leg it lies beneath the peroneus longus, upon the fibula, and between the intermuscular septa separating it from the muscles on the front and back of the leg. Between it and the peroneus longus in the leg is the musculo-cutaneous (*superficial peroneal*) nerve.

Nerve Supply.—The nerve supply of both muscles is derived from the musculo-cutaneous (*superficial peroneal*) nerve.

Action.—The action of the peronei muscles is to evert, and to assist in extension of the foot. In the form of club-foot known as talipes valgus these tendons require division.

Traumatic forward displacement of the tendons of the peroneus longus and peroneus brevis from their grooves behind the malleolus sometimes occurs; in such a case the tendons become prominent under the integument and the patient suffers from pain and lameness.

Dissection.—Reflect the proximal part of the peroneus longus muscle, when the external popliteal (*common peroneal*) nerve will be seen dividing into its two terminal branches.

The External Popliteal (Common Peroneal) Nerve.—Immediately below the head of the fibula, between the neck of the bone and the peroneus longus muscle, the external popliteal (*common peroneal*) nerve gives off the recurrent articular nerve, and divides into the anterior tibial (*deep peroneal*) and musculo-cutaneous (*superficial peroneal*) nerves.

The **recurrent articular nerve** which arises at the termination of the external popliteal (*common peroneal*) pierces the extensor digitorum longus and is largely distributed to the tibialis anterior muscle. Some of its fibers accompany the anterior tibial recurrent artery to the front of the knee-joint. It also gives off articular branches to the tibio-fibular joint and cutaneous branches which will be described with the back of the leg.

The **anterior tibial (deep peroneal) nerve** pierces the extensor digitorum longus muscle and accompanies the anterior tibial artery, as already described. It supplies the tibialis anterior, extensor digitorum longus, extensor hallucis longus, peroneus tertius, and extensor digitorum brevis muscles and sends a small articular branch to the ankle-joint. It passes behind the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*) and divides into medial and lateral branches. The medial branch supplies the adjacent sides of the dorsal surface of the great and second toes.

The **musculo-cutaneous (superficial peroneal) nerve** passes forward and downward through the substance of the peroneus longus muscle, then between the peroneus longus and peroneus brevis muscles, and lastly between the peroneus brevis and the extensor digitorum longus, where it divides into two branches, a medial and a lateral. These two branches pierce the deep fascia at the junction of the middle with the distal third of the leg to reach the superficial fascia, as already described. The musculo-cutaneous (*superficial peroneal*) nerve supplies the peroneus longus and peroneus brevis muscles. It also supplies the medial side of the great toe and adjacent sides of the second and third, and of the third and fourth toes on the dorsal surface. In a lean subject, with the foot in the

position of strong adduction, this nerve can often be seen as a subcutaneous cord, and should not be mistaken for a tendon.

Injuries of the Nerves.—These nerves, like the blood-vessels, are liable to injury in fractures and wounds. Division of the external popliteal (*common peroneal*) nerve, or any sensory motor nerve, of course, results in paralysis of the parts supplied by the same. The author has sutured a divided external popliteal (*common peroneal*) nerve one and a half years after the injnry, and obtained complete restoration of the function of the limb.

Pressure upon, and inflammation of the peroneal (*common peroneal*) nerve lead to paralysis of the muscles supplied by it, and "foot-drop" occurs. In this condition when the patient attempts to walk the great toe is stubbed against the ground, and in order to prevent this he will raise the entire leg as if stepping over obstacles (*steppage gait*). In all cases of "foot drop" the foot should be fixed in dorsiflexion to prevent lengthening of the extensor tendon.

THE DORSUM OF THE FOOT

The **deep fascia** covering the dorsum of the foot is a thin membranous layer continuous above with the lower margin of the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*), and on each side with the lateral portions of the plantar fascia. It extends forward to the toes.

Dissection.—Remove this fascia and expose the muscles, tendons, vessels, and the anterior tibial (*deep peroneal*) nerve. The tendons of the extensor digitorum longus and peroneus tertius muscles should be cut through just below the annular ligament (*lig. transversum cruris and cruciatum cruris*), and reflected toward the toes; the extensor digitorum brevis muscle can then be examined.

The **extensor digitorum brevis** is a broad thin muscle which *arises* from the front and lateral surface of the os calcis (*calcaneus*) anterior to the groove for the peroneus brevis muscle, from the external calcaneo-astragaloid (*lateral talo-calcaneal*) ligament, and from the anterior annular ligament (*lig. transversum cruris and cruciatum cruris*). It passes forward and medialward as four bellies to *terminate* in four tendons which are attached to the four medial toes. The most medial tendon, the largest, crosses the dorsalis pedis artery, and, becoming expanded, is *inserted* into the base of the proximal phalanx of the great toe; the remaining three join the fibular side of the long extensor tendons to be inserted with them into the bases of the second and distal phalanges. The muscle lies beneath the tendons of the extensor digitorum longus and peroneus tertius muscles. Its medial belly is a guide in finding the dorsalis pedis artery.

Nerve Supply.—The nerve supply is from the anterior tibial (*deep peroneal*) nerve.

Action.—Its action is to assist the long extensor tendons in extending the four medial toes, as well as to draw them toward the fibular side.

The **dorsalis pedis artery,** the continuation of the anterior tibial, begins on the front of the ankle, between the malleoli, runs over the instep to the interval between the first and second metatarsal bones, where it divides into two terminal branches, the dorsalis hallucis (*first dorsal metatarsal*) and a communicating (*deep plantar*) branch. A line drawn from the center of the intermalleolar space in front, to a point midway between the great and second toes will represent its course. The artery lies upon the astragalus (*talus*), the scaphoid (*navicular*), and the internal (*first*) cuneiform bones, but is separated from them by their dorsal ligaments. It is covered by skin, superficial and deep fascia, and the medial margin of the extensor digitorum brevis muscle, and is crossed by the most medial tendon of this muscle. It lies between the tendons of the extensor hallucis longus on its medial side, and the most medial tendon of the extensor digitorum longus and the medial belly of the extensor digitorum brevis on its lateral side. It is accompanied by two veins and the anterior tibial (*deep peroneal*) nerve, which lies to its lateral side. In cases where the dorsalis pedis artery is absent, its place is supplied by the anterior peroneal (*perforating*) branch of the peroneal artery.

The **branches of the dorsalis pedis artery** are the tarsal (*lateral tarsal*), the metatarsal (*arcuate*), the dorsalis hallucis (*first dorsal metatarsal*), and the communicating (*deep plantar*).

The *tarsal* (*lateral tarsal*) *branch* arises opposite the scaphoid (*navicular*) bone and arches laterally beneath the extensor digitorum brevis muscle toward the lateral side of the foot, supplying this muscle, the bones, and the joints of the tarsus. It anastomoses with the metatarsal (*arcuate*), the lateral malleolar, the anterior peroneal (*perforating*), and the lateral plantar arteries.

The *metatarsal* (*arcuate*) *branch* forms the dorsal arch of the foot. It passes lateralward beneath the tendons of the extensor digitorum brevis near the bases of the metatarsal bones, and, reaching the lateral side of the foot, anastomoses with the tarsal (*lateral tarsal*) and lateral plantar arteries. Its branches are the dorsal interosseous arteries.

The metatarsal (*arcuate*) artery gives off three lateral *dorsal interosseous* (*dorsal metatarsal*) *arteries*, which pass forward upon the corresponding three lateral dorsal interossei muscles, which they supply. At the clefts of the toes each divides into two branches for the supply of the adjacent sides of the second and third, and fourth and fifth toes, the most lateral interosseous (*dorsal metatarsal*) giving off a small twig to supply the lateral side of the fifth toe. At the proximal part of the interosseous spaces they are joined by the posterior perforating

branches of the plantar arch, and at the distal part they receive the anterior perforating branches from the digital arteries.

The two succeeding vessels are the *terminal divisions of the dorsalis pedis*, the dorsalis hallucis (*first dorsal metatarsal*) being the apparent continuation of the primary trunk.

The *dorsalis hallucis* (*first dorsal metatarsal*) *artery* extends forward over the first interosseous space, and at the cleft between the first and second toes divides into two branches. One of these passes beneath the tendon of the extensor hallucis *longus* muscle to be distributed to the medial side of the great toe; the other divides into two branches to supply the adjacent sides of the great and second toes.

The *communicating* (*deep plantar*) *artery* passes into the sole of the foot between the two heads of the first dorsal interosseous muscle, and anastomoses with the terminal portion of the lateral plantar artery, thus completing the plantar arch. The relation which this vessel bears to the first dorsal interosseous muscle of the foot is similar to that borne by the radial artery to the first dorsal interosseous muscle of the hand.

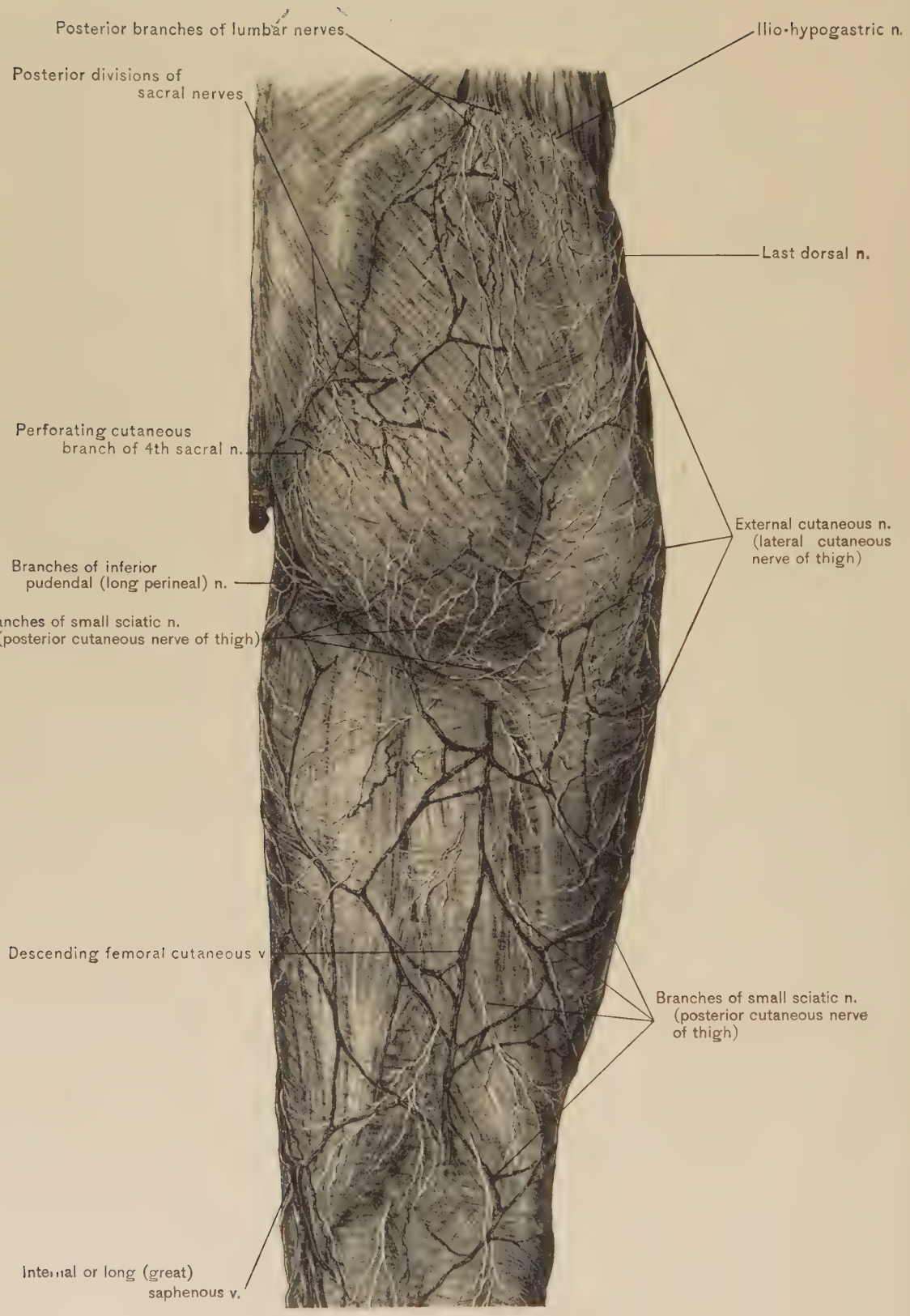
THE BUTTOCKS

Place the body face downward with a block under the pelvis, and rotate the thigh medialward. Carry an incision along the whole length of the crest of the ilium, over the middle of the sacrum to the tip of the coccyx, then obliquely forward to the incision on the medial side of the thigh. Reflect the skin downward and lateralward.

The skin of the buttock is thick and coarse and only slightly movable on the underlying parts. Its blood supply is not so free as in other parts of the surface of the body.

The superficial fascia now exposed is loosely attached and contains a large quantity of fat. Owing to the comparatively large amount of fat, the buttocks are a favorable locality for lipomata. Over the ischial tuberosity the adipose tissue is thicker and denser than elsewhere and forms a cushion beneath which a bursa is frequently found, the so-called "weaver's bottom." It is due to the fat contained in the superficial fascia, rather than to the muscular development, that the buttock is round and prominent; this is especially the case in women. Flattening of the buttocks, an early symptom of hip-joint disease, is not due to the absorption of the fat and atrophy of the muscles, as sometimes stated, but to the flexion and lateral rotation of the hip. The looseness of the superficial fascia permits large effusions to take place in this region, so that in contusions of the buttock the ecchymosis is more pronounced than in other parts of the body.

PLATE CCC.


Posterior branches of lumbar nerves
Ilio-hypogastric n.
Posterior divisions of sacral nerves
Last dorsal n.
Perforating cutaneous branch of 4th sacral n.
External cutaneous n. (lateral cutaneous nerve of thigh)
Branches of inferior pudendal (long perineal) n.
Branches of small sciatic n. (posterior cutaneous nerve of thigh)
Descending femoral cutaneous v
Branches of small sciatic n. (posterior cutaneous nerve of thigh)
Internal or long (great) saphenous v.

CUTANEOUS VESSELS AND NERVES OF THE BACK OF THE LOWER EXTREMITY.

The **cutaneous nerves of the buttocks** (Plate CCC), from before backward, are as follows:

Branches from the external cutaneous nerve (lateral cutaneous nerve of thigh) are distributed over the greater trochanter.

Branches from the small sciatic nerve (posterior cutaneous nerve of thigh) wind around the inferior border of the gluteus maximus and supply the skin and fascia over the lower part of this muscle. The *perforating cutaneous branch* of the fourth sacral nerve also supplies the inferior portion of the gluteal cutaneous surface, and, after piercing the great sacro-sciatic (*sacro-tuberous*) ligament, and winding around the inferior border of the gluteus maximus muscle, usually appears lateral to the ischial tuberosity.

Passing over the crest of the ilium a short distance behind the anterior superior spine of the ilium is the *lateral cutaneous branch of the last dorsal nerve*, which is distributed to the skin and fascia, some of its filaments extending as low as the greater trochanter.

Behind the last-named branch, and crossing the crest of the ilium a little in advance of its middle, is the *iliac branch (lateral cutaneous branch) of the ilio-hypogastric nerve.*

Passing over the posterior part of the crest of the ilium are *cutaneous branches of the posterior divisions of the upper three lumbar nerves.*

Cutaneous filaments from the lateral branches of the posterior divisions of the three upper sacral nerves pierce the gluteus maximus muscle near its origin and supply the skin and fascia over the extreme posterior part of the gluteal region.

The cutaneous vessels in the gluteal region are branches of the gluteal (*superior gluteal*), the sciatic (*inferior gluteal*), and the external (*lateral*) circumflex arteries.

Dissection.—Reflect the superficial fascia by making an incision similar to that made in reflecting the skin.

The deep fascia of the buttock, or the gluteal fascia, a very important structure, is continuous with the deep fascia of the thigh, and, near the coccyx, with the anal fascia. It is attached above to the crest of the ilium and behind to the sacrum, coccyx, and great sacro-sciatic (*sacro-tuberous*) ligament. It is much thicker in front, where it covers the gluteus medius muscle, than behind, where it covers the gluteus maximus; in the latter situation it is comparatively thin. At the anterior border of the gluteus maximus the deep fascia divides into two layers, the superficial layer covering the upper surface of the muscle, the deep layer covering its under surface, thus encasing the muscle in the split fascia.

The superficial layer of the gluteal fascia, in passing over the gluteus maximus muscle, sends septa into the muscle to encase bundles of fibers. It is on

account of these septa that the muscle is so hard to clean and presents a coarse appearance.

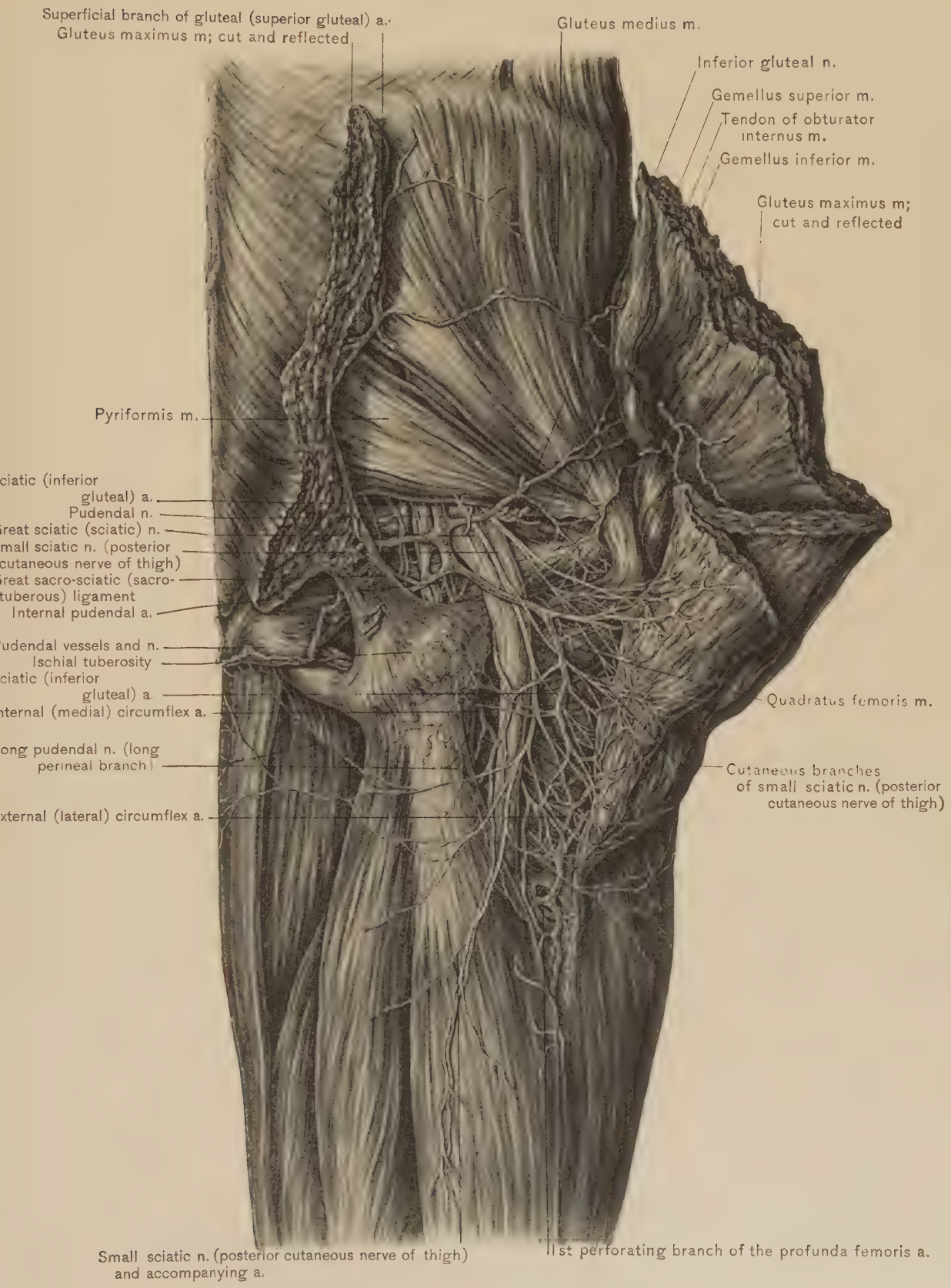
Extravasations of blood beneath this fascia will not discolor the skin and may be mistaken for abscess. Deep inflammations beneath this fascia, especially beneath the gluteus medius, may cause severe pain, owing to the inflammatory effusions being held between a wall of bone on one side and strong fascia and thick muscles on the other. Pus so confined may travel a considerable distance down the thigh before it reaches the surface, in fact, a gluteal abscess may travel to the ankle before it becomes superficial. Sometimes the pus may find its way into the pelvis through the sciatic foramina, or a pelvic abscess may escape through one of these foramina and form a deep collection in the buttock. The ilio-tibial band, or tract (described with the fascia lata of the thigh), is tightly stretched across the gap between the crest of the ilium and the greater trochanter. By making pressure on the fascia between these bony points, the amount of resistance it is capable of offering can be readily appreciated. In fractures of the neck of the femur, when the greater trochanter is made to approach nearer to the crest of the ilium, this band will be relaxed. Allis has drawn attention to this relaxation of the fascia as of value in the diagnosis of fracture of the neck of the femur.

Dissection.—Remove the superficial layer of the deep fascia. This requires care in order not to take with it a portion of the gluteus maximus muscle. The latter is the most difficult muscle in the body to clean, but by keeping the fascia wet with a dampened sponge, and cutting across the line of the fibers of the muscle, the gluteus maximus can be cleaned very nicely.

The **Muscles of the Gluteal Region** (Plate CCCI) are: the gluteus maximus, gluteus medius, gluteus minimus, pyriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and quadratus femoris.

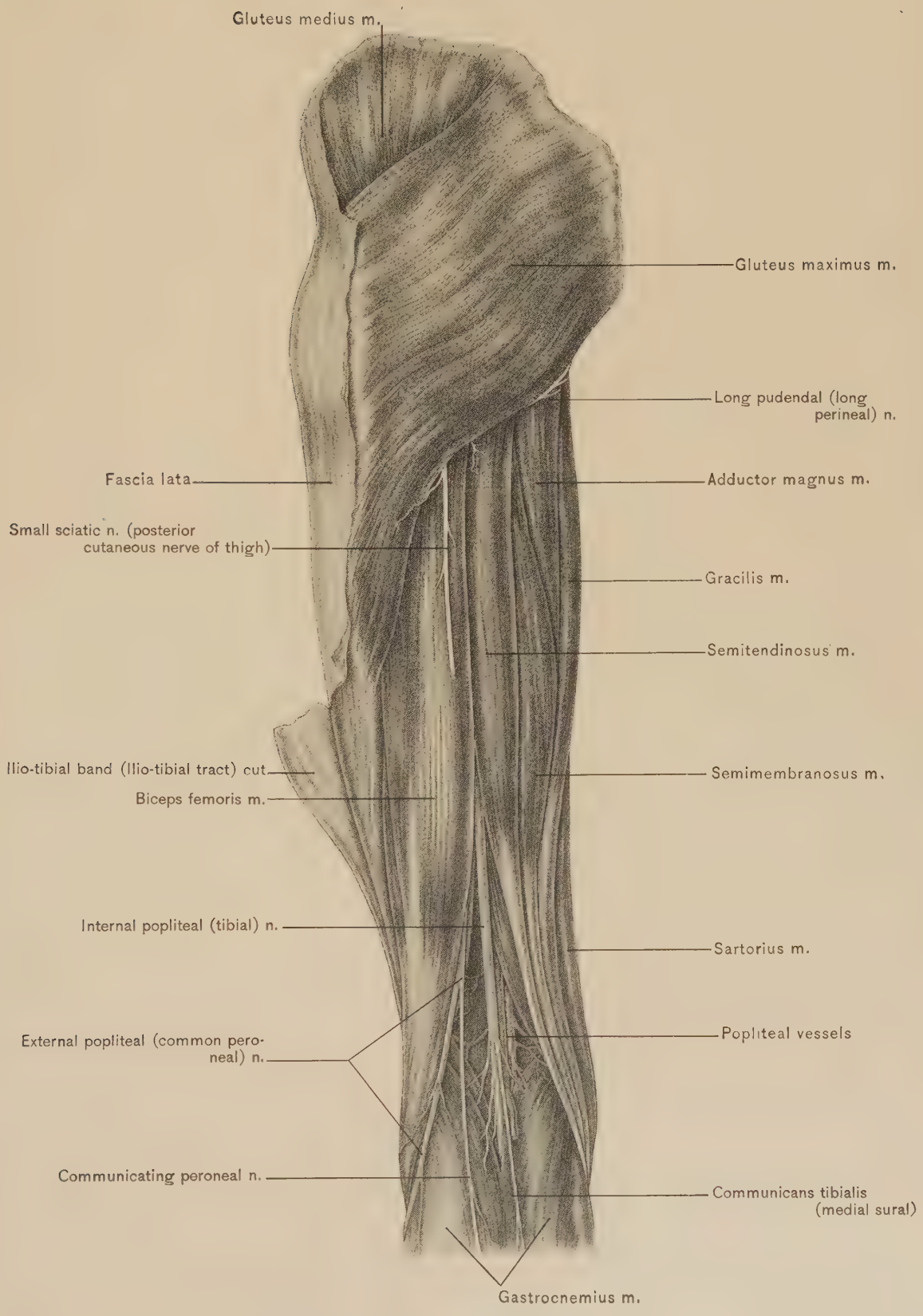
The **gluteus maximus** (Plate CCCII) is the largest muscle of the body and the most superficial one of the buttock. It *arises* from the posterior fourth of the crest of the ilium, the rough surface of the ilium immediately below, from the lumbar aponeurosis at its attachment to the crest of the ilium, from the posterior surface of the fourth and fifth pieces of the sacrum, from the coccyx, from the fascia covering the gluteus medius muscle, and from the great sacro-sciatic (*sacro-tuberous*) ligament. The fibers pass obliquely downward, lateralward, and forward. The anterior two-thirds of the muscle is *inserted* into the deep fascia on the lateral side of the thigh, the ilio-tibal band; the posterior and distal third is *inserted* into the gluteal ridge (*gluteal tuberosity*), the rough line of the femur leading from the greater trochanter to the linea aspera, between the vastus externus (*vastus lateralis*) and the adductor magnus.

PLATE CCCI.


Superficial branch of gluteal (superior gluteal) a.
Gluteus maximus m; cut and reflected
Gluteus medius m.
Inferior gluteal n.
Gemellus superior m.
Tendon of obturator internus m.
Gemellus inferior m.
Gluteus maximus m; cut and reflected
Pyriformis m.
ciatic (inferior gluteal) a.
Pudendal n.
reat sciatic (sciatic) n.
mall sciatic n. (posterior cutaneous nerve of thigh)
reat sacro-sciatic (sacro-tuberous) ligament
Internal pudendal a.
udendal vessels and n.
Ischial tuberosity
ciatic (inferior gluteal) a.
nternal (medial) circumflex a.
ong pudendal n. (long perineal branch)
xternal (lateral) circumflex a.
Quadratus femoris m.
Cutaneous branches of small sciatic n. (posterior cutaneous nerve of thigh)
Small sciatic n. (posterior cutaneous nerve of thigh) and accompanying a.
1st perforating branch of the profunda femoris a.

GLUTEAL REGION WITH GLUTEUS MAXIMUS REFLECTED.

PLATE CCCII.



GLUTEUS MAXIMUS AND FLEXORS.

Bursæ beneath the gluteus maximus.—There are three bursæ beneath the gluteus maximus muscle: one between the muscle and the tuberosity of the ischium; another between the fascial insertion and the greater trochanter, and a third between the bony insertion and the vastus externus (*vastus lateralis*) muscle. Of these, the one between the fascial insertion and the greater trochanter, which is multilocular, is the most important. Inflammation of this bursa causes severe pain in moving the limb, the thigh being generally in the position of flexion and abduction. Caries of the greater trochanter may follow suppuration of this bursa, owing to its close relation to the bone. To the inexperienced observer, inflammation of this bursa may be mistaken for hip disease; but if there is no swelling of the joint, and the head of the femur can be rotated in the acetabulum without exciting pain, and the swelling and tenderness are over the site of the bursa, there should be no mistake. The bursa over the tuberosity of the ischium may become inflamed in those who sit a great deal, such as coachmen, weavers, etc., as it is pressed upon in the sitting posture. When enlarged, it constitutes the disease formerly named "weaver's bottom," and may cause pain from pressure upon the inferior pudendal (*long perineal*) nerve.

The gluteus maximus muscle, owing to its situation in forming the prominence of the buttock, its coarseness, and the fact that it protects the hip-joint and passes over the greater trochanter, may be likened to the deltoid muscle, which is also coarse, and covers the shoulder-joint and the greater tuberosity of the humerus. The superior border overlies the gluteus medius, while the inferior, much the thicker and longer, bounds the ischio-rectal fossa and extends obliquely across the back of the thigh over the flexor muscles. Beneath the inferior border pass the sciatic vessels and nerves. In the extended position of the femur the gluteus maximus muscle covers the tuber ischii; when the limb is flexed on the pelvis, the tuberosity is uncovered by the muscle. Superficially, it is in relation with the fat of the buttock and with the superficial nerves; deeply, with the gluteus medius, pyriformis, gemelli and obturator internus, quadratus femoris, adductor magnus, biceps femoris, semitendinosus and semimembranosus muscles; the gluteal (*superior gluteal*), sciatic (*inferior gluteal*), and pudendal vessels, the great sciatic (*sciatic*) and the small sciatic (*posterior cutaneous nerve of thigh*) nerves, the nerve to the obturator internus muscle and the pudendal nerve, the sacro-sciatic (*sacro-tuberous and sacro-spinous*) ligaments, the tuber ischii, and the greater trochanter.

Guiteras has described a space which he calls the "*subgluteal triangle.*" It is bounded laterally by the line of attachment of the gluteus maximus to the femur and by the greater trochanter, medially by the long head of the biceps femoris, tuber ischii, and part of the great sacro-sciatic (*sacro-tuberous*) ligament, and above by the pyriformis. Its floor is formed by the gemellus superior and

inferior, the obturator, quadratus femoris, and adductor magnus muscles. The contents are the greater sciatic (*sciatic*) and lesser sciatic (*posterior cutaneous*) nerves, the internal pudendal nerve and the nerve to the obturator internus muscle, the sciatic (*inferior gluteal*) and internal pudendal arteries and branches of the profunda femoris artery, together with fatty tissue, lymphatics, and bursæ. All thes parts are covered by the gluteus maximus muscle.

Nerve Supply.—It is supplied by the inferior gluteal nerve and by branches of the small sciatic nerve (*posterior cutaneous nerve of thigh*).

Action.—The gluteus maximus muscle acts as an extensor, lateral rotator and abductor of the thigh, and also as a tensor of the fascia lata. In extending the thigh it assists in raising the body from the sitting to the standing posture, and while in the latter position, fixes the knee-joint by making tense the ilio-tibial band, in which action it is assisted by the tensor fasciæ femoris (*tensor fasciæ latæ*).

Dissection.—Cut through the muscle near its origin until the layer of fascia lining its under surface, which serves as a guide in its removal, is reached. Reflect it with the layer of fascia downward and lateralward, tracing the vessels and nerves which enter its under surface. They are the inferior gluteal vessels and nerve, and branches of the superior gluteal artery. Remove the areolar tissue and fat from the area covered by the muscle, and expose the following structures: the posterior portion of the gluteus medius muscle, below which is the pyriformis. Emerging from between the pyriformis and the gluteus medius, is seen the gluteal (*superior gluteal*) artery; from beneath the pyriformis, the great sciatic (*sciatic*) and small sciatic (*posterior cutaneous nerve of thigh*) nerves, the sciatic (*inferior gluteal*) vessels, and the inferior gluteal nerve make their appearance. Besides the above-mentioned structures are seen the branch of the sciatic artery (*inferior gluteal*) accompanying the great sciatic (*sciatic*) nerve; winding over the spine of the ischium, the internal pudendal vessels, the pudendal nerve, and the nerve to the obturator internus muscle; the tendon of the obturator internus muscle between the superior and inferior gemelli muscles; the quadratus femoris muscle and the upper border of the adductor magnus, with the terminal branch of the internal (*medial*) circumflex artery passing between them; the origins of the semimembranosus, biceps, and semitendinosus muscles; the greater trochanter and the overlying bursa, a small part of the vastus externus (*vastus lateralis*) muscle, the tuberosity of the ischium with its bursæ, the great sacro-sciatic (*sacro-tuberous*) ligament, pierced by the coccygeal branch of the sciatic (*inferior gluteal*) artery and the perforating cutaneous branch of the fourth sacral nerve; the coccyx, the side of the sacrum, and the posterior part of the crest of the ilium with the rough surface of bone beneath. The gluteal (*superior gluteal*) artery, the

superior and inferior gluteal nerves, the pyriformis muscle, the great sciatic (*sciatic*) and small sciatic (*posterior cutaneous nerve of thigh*) nerves, the sciatic (*inferior gluteal*) artery, the pudenal artery and nerve, the nerve to the obturator internus, and the nerve to the quadratus femoris come out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen. The tendon of the oburator internus emerges through the small sacro-sciatic (*lesser sciatic*) foramen. Beneath the quadratus femoris muscle lies the tendon of the obturator externus. To expose the latter necessitates division of the quadratus femoris.

Remove the fascia covering the gluteus medius muscle.

The **gluteus medius muscle** is triangular in shape with its base attached to the ilium and its apex to the greater trochanter of the femur. Its anterior portion is covered by the fascia lata, and the smaller posterior portion by the gluteus maximus. It *arises* from the dorsum of the ilium between the superior (*posterior*) curved line and the crest above, and the middle (*anterior*) curved line below; from the anterior four-fifths of the lateral lip of the crest, and from the fascia covering the muscle. The fibers converge to a strong tendon which is *inserted* into the oblique line on the lateral surface of the greater trochanter. Between the tendon and the upper part of the trochanter is a small bursa. Superficial to it are the fascia lata, and the gluteus maximus and tensor fasciæ femoris (*tensor fasciæ latæ*) muscles. Its deep relations are the gluteus minimus, the superior gluteal vessels and nerve, and the greater trochanter.

Nerve Supply.—From the superior gluteal nerve.

Action.—The gluteus medius muscle is an abductor of the thigh and assists in balancing the pelvis on the thigh when standing on one leg; it is also both a medial and a lateral rotator, the anterior fibers performing the part of the medial, and the posterior fibers that of the lateral rotator.

Dissection.—Cut across the gluteus medius near its origin and reflect it downward. This will expose the gluteus minimus muscle, the superior gluteal nerve, and the gluteal (*superior gluteal*) artery, a branch of which is a guide in separating the gluteus medius from the gluteus minimus. Trace the branches of the gluteal (*superior gluteal*) artery and the superior gluteal nerve which enter its under surface, and divide them. In relation with the anterior border of the gluteus medius muscle is the tensor fasciæ femoris (*tensor fasciæ latæ*) muscle. Along its posterior border is the pyriformis muscle.

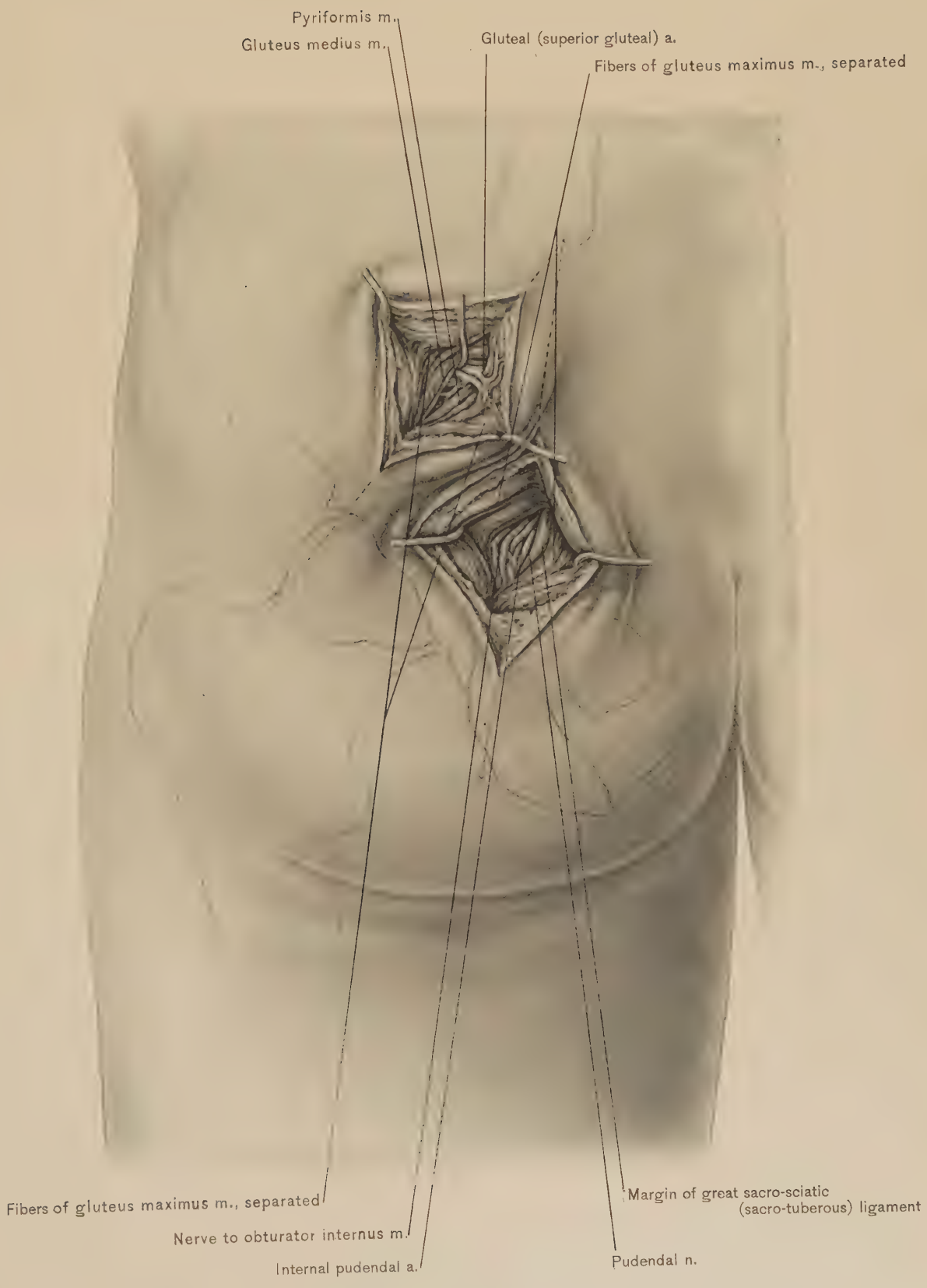
The **gluteal** (**superior gluteal**) **artery,** the terminal branch of the posterior trunk of the internal iliac, leaves the pelvis through the great sacro-sciatic (*greater sciatic*) foramen above the upper border of the pyriformis muscle. It passes between the pyriformis and the gluteus minimus muscles and divides into a superficial and a deep branch. The *superficial branch* passes between the pyriformis

and gluteus medius to the gluteus maximus which it supplies, together with the overlying integument. It anastomoses with the posterior branches of the lateral sacral arteries, and with the sciatic (*inferior gluteal*) and the deep circumflex iliac arteries. The *deep branch*, the continuation of the artery, bifurcates between the gluteus medius and minimus muscles into a superior and an inferior branch. The *superior branch*, accompanied by the superior branch of the superior gluteal nerve, passes along the upper border of the gluteus minimus muscle (being a guide in the separation of the gluteus medius and gluteus minimus) to the anterior part of the ilium, where it anastomoses with the superficial and deep circumflex iliac arteries, and the ascending branches of the external (*lateral*) circumflex artery. The *inferior branch*, accompanied by the inferior branch of the superior gluteal nerve, crosses the gluteus minimus obliquely toward the anterior inferior spine of the ilium and anastomoses with the ascending branch of the external (*lateral*) circumflex. The accompanying veins of the gluteal (*superior gluteal*) artery have the same relations as the artery, and in the pelvis become the posterior trunk of the external iliac vein. The gluteal (*superior gluteal*) artery is about the size of the ulnar artery. Wounds of the buttock will involve only its branches, since a very small portion of the main trunk is seen outside of the pelvis. Hemorrhage from the terminal branches of the gluteal (*superior gluteal*) artery may be controlled by compression of the internal iliac through the rectum. Similar pressure, however, is not of much benefit in gluteal aneurysm. Pressure of an aneurysm of the gluteal artery within the pelvis, because of the relation of the artery to the sacral plexus, produces symptoms of nerve irritation.

Ligation of the Gluteal (Superior Gluteal) Artery (Plate CCCIII).—The gluteal (*superior gluteal*) artery can be ligated in the buttock, through an incision carried in a line drawn from the posterior superior spine of the ilium to the greater trochanter, with the thigh rotated medialward. The junction of the medial with the intermediate third of this line marks the point of exit of the artery through the great sacro-sciatic (*greater sciatic*) foramen, and should correspond to the center of the incision.

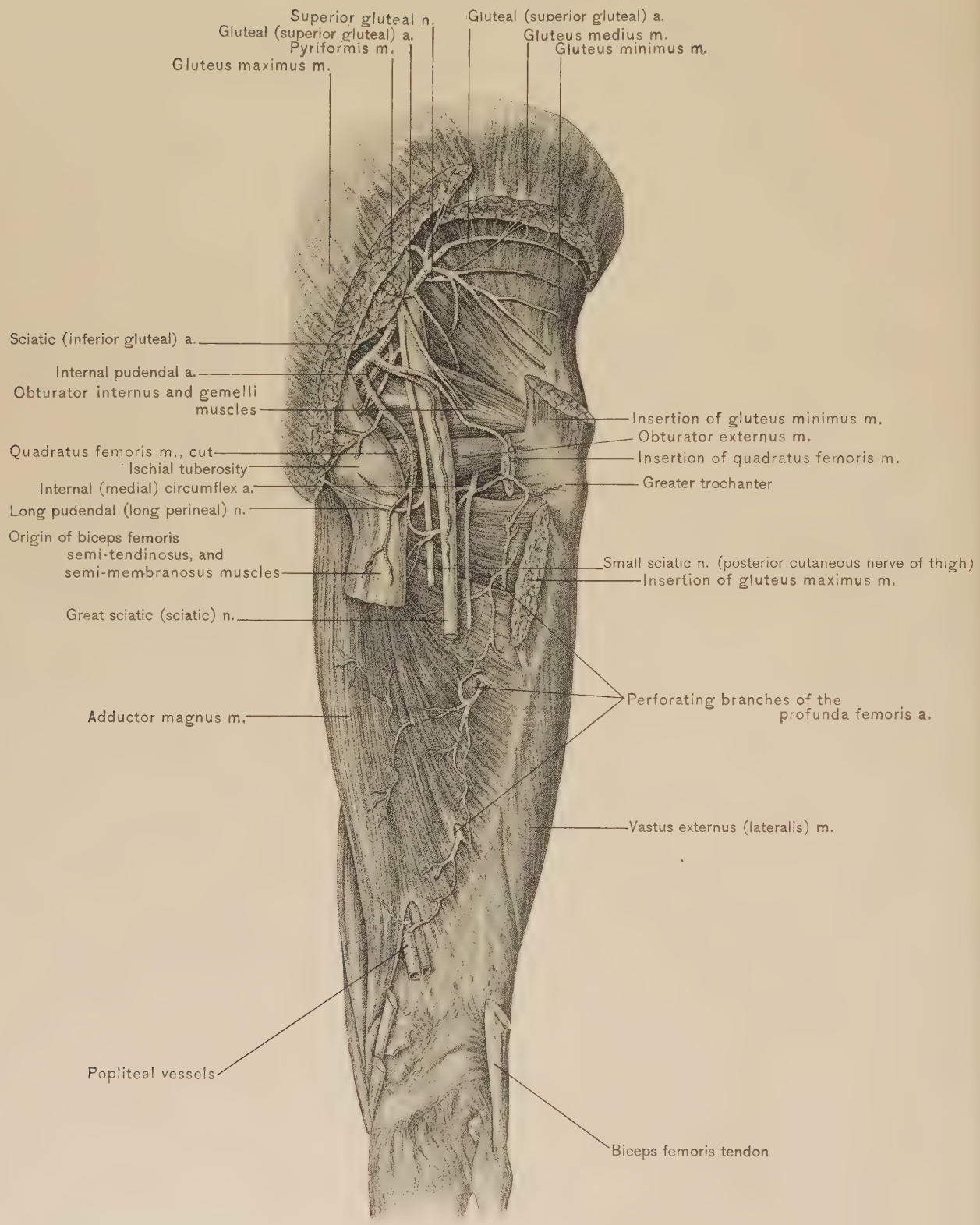
The **superior gluteal nerve** arises from the fourth and fifth lumbar and first sacral nerves. It accompanies the gluteal (*superior gluteal*) artery, passing out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen above the pyriformis muscle. Immediately after the nerve reaches the gluteal region it divides into two branches. The *superior branch* accompanies the superior branch of the deep division of the gluteal (*superior gluteal*) artery, and supplies the gluteus medius and minimus muscles. The *inferior branch* accompanies the inferior branch of the deep division of the gluteal (*superior gluteal*) artery, crosses

PLATE CCCIII.


Pyriformis m.
Gluteus medius m.
Gluteal (superior gluteal) a.
Fibers of gluteus maximus m., separated
Fibers of gluteus maximus m., separated
Nerve to obturator internus m.
Internal pudendal a.
Margin of great sacro-sciatic (sacro-tuberous) ligament
Pudendal n.

LIGATION OF GLUTEAL (SUPERIOR GLUTEAL) ARTERY AT ITS POINT OF EXIT AND OF INTERNAL PUDENDAL ARTERY.

PLATE CCCIV.


Superior gluteal n.
Gluteal (superior gluteal) a.
Pyriformis m.
Gluteus maximus m.
Gluteal (superior gluteal) a.
Gluteus medius m.
Gluteus minimus m.
Sciatic (inferior gluteal) a.
Internal pudendal a.
Obturator internus and gemelli muscles
Quadratus femoris m., cut
Ischial tuberosity
Internal (medial) circumflex a.
Long pudendal (long perineal) n.
Origin of biceps femoris semi-tendinosus, and semi-membranosus muscles
Great sciatic (sciatic) n.
Adductor magnus m.
Popliteal vessels
Insertion of gluteus minimus m.
Obturator externus m.
Insertion of quadratus femoris m.
Greater trochanter
Small sciatic n. (posterior cutaneous nerve of thigh)
Insertion of gluteus maximus m.
Perforating branches of the profunda femoris a.
Vastus externus (lateralis) m.
Biceps femoris tendon

GLUTEUS MINIMUS, GLUTEAL (SUPERIOR GLUTEAL) ARTERY, GLUTEAL NERVES, AND OBTURATOR EXTERNUS MUSCLE.

the gluteus minimus muscle obliquely, and distributes branches to the gluteus medius and minimus and tensor fasciæ femoris (*tensor fasciæ latæ*) muscles.

The **gluteus minimus** (Plate CCIV), the smallest of the three gluteus muscles, is triangular in shape and is slightly overlapped, posteriorly, by the pyriformis. It *arises* from the dorsum of the ilium between the middle (*anterior*) and inferior curved lines as far back as the margin of the great sacro-sciatic (*greater sciatic*) notch. Its fibers converge to a flattened tendon which covers the lower part of the muscle and is *inserted* into a depression upon the anterior part of the greater trochanter. The muscle passes over the capsule of the hip-joint, to which the tendon at its insertion is closely connected. Between the tendon and the greater trochanter is a synovial bursa. Superficial to it are the gluteus medius muscle and the superior gluteal vessels and nerve. Its deep relations are the capsule of the hip-joint and the posterior (reflected) head of the rectus femoris muscle.

Nerve Supply.—From the superior gluteal nerve.

Action.—The gluteus minimus is an abductor and a medial rotator of the thigh. It also assists in flexing the thigh on the abdomen. Taking its fixed point from the femur, it acts upon the pelvis, supporting it and the whole trunk upon the head of the femur, as in standing upon one leg, and also throws the opposite side of the pelvis forward in walking.

Dissection.—Cut through the gluteus minimus muscle near its origin and reflect it; this will expose the long head (reflected tendon) of the rectus femoris muscle, which occupies the groove above the margin of the acetabulum, the capsular ligament of the hip-joint, and the bursa between the tendon and the greater trochanter.

The **pyriformis muscle** lies immediately below the inferior border of the gluteus medius and almost parallel with it. It *arises* within the pelvis from the front of the second, third, and fourth pieces of the sacrum, between and lateral to the foramina; from the upper margin of the great sacro-sciatic (*greater sciatic*) notch; and from the deep surface of the greater sacro-sciatic (*sacro-tuberous*) ligament. It passes out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen, and terminates in a rounded tendon which is *inserted* into the upper border of the greater trochanter, between the gluteus medius and minimus muscles. It divides the great sacro-sciatic (*greater sciatic*) foramen into two parts: the upper part gives passage to the gluteal vessels and the superior gluteal nerve; and the lower part to the great sciatic (*sciatic*) and small sciatic (*posterior cutaneous nerve of thigh*), the inferior gluteal, and the pudendal nerves; the nerves to the obturator internus and quadratus femoris muscles; and the internal pudendal and sciatic (*inferior gluteal*) vessels. In front of it, within the pelvis, are the sacral plexus, internal iliac vessels and some of their branches, and the rectum, especially on

the left side. Outside of the pelvis it rests upon the capsule of the hip-joint and the innominate bone. Behind it in the pelvis is the sacrum. Outside of the pelvis it is covered by the gluteus maximus. Its border is in relation with the gluteus medius muscle, and the superior gluteal vessels and nerve; its lower border, with the inferior gluteal nerve, the coccygeus muscle, the sciatic (*inferior gluteal*) and internal pudendal vessels, the great sciatic (*sciatic*) and small sciatic nerves (*posterior cutaneous nerve of thigh*), and the nerves to the obturator internus and quadratus femoris muscles. When the great sciatic (*sciatic*) nerve divides within the pelvis, the muscle is sometimes pierced by the external popliteal (*common peroneal*) nerve. The muscle is occasionally absent.

Nerve Supply.—The pyriformis receives its nerve supply from the sacral plexus.

Action.—The pyriformis is a lateral rotator of the extended thigh and an abductor of the flexed thigh.

Dissection.—The pyriformis should be cut across and reflected toward the sacrum, when the great sciatic (*sciatic*) nerve, the small sciatic nerve (*posterior cutaneous nerve of thigh*) and the sciatic (*inferior gluteal*) vessels and the pudendal nerve and vessels can be seen leaving the pelvis; their course and relations should be carefully studied before completing the dissection of the muscles of this region.

The **great sciatic (sciatic) nerve** (Plate CCCV) is the largest in the body. It is the continuation of the sacral plexus formed by the anterior branches of the fourth and fifth lumbar nerves and the first three sacral nerves. It passes out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen below the pyriformis muscle. It occasionally divides at its origin into its two terminal branches. When this is the case, the external popliteal (*common peroneal*) nerve usually pierces the pyriformis muscle. It descends through the interval between the tuberosity of the ischium and the greater trochanter, lying a little nearer the former, and thence along the back of the thigh.

Just below the middle of the thigh it usually divides into its two terminal branches, the internal popliteal (*tibial*) and external popliteal (*common peroneal*) nerves. It rests upon the gemellus superior, the obturator internus, the gemellus inferior, the quadratus femoris, and the adductor magnus muscles. In the thigh, as will be seen in its dissection, the nerve lies upon the adductor magnus to the lateral side of the semimembranosus and is covered by the long head of the biceps femoris. It is accompanied for a variable distance by a branch of the sciatic (*inferior gluteal*) artery, the comitans nervi ischiadici, which finally enters its substance.

The branches of the great sciatic (*sciatic*) nerve are articular and muscular.

PLATE CCCV.

GREAT SCIATIC (SCIATIC) NERVE.

The *articular branches* are distributed to the hip-joint and perforate the capsule posteriorly. The *muscular branches* supply the adductor magnus, the semimembranosus, the semitendinosus, and the biceps femoris muscles.

The relationship of the sciatic nerve to hip-joint injuries, especially dislocation, is of great importance. The nerve is in close relation with the hamstring muscles, especially the biceps femoris. These muscles are tightly stretched across the neck of the femur by flexion of the thigh on the abdomen, especially if the leg is also extended on the thigh, so that the origin and the insertion of the muscles are separated. If the head lies originally in the anterior plane of the pelvis and either by reason of the dislocating force, of muscular action, or of efforts at reduction is made to pass to the posterior plane, it must pass through the narrow space between the great sciatic (*sciatic*) nerve and the hamstrings and the edge of the acetabulum. The nerve is thus apt to be stretched and injured, and separated somewhat from the biceps femoris tendon. If still later the Bigelow, or circumduction, method of reduction is attempted the head will pass beneath the nerve which will become tightly stretched over the anterior aspect of the neck. When this occurs full extension is prevented and the patient complains of pain and disability.

Sciatica.—The form of neuritis known as sciatica involves this nerve, and may be due to cold (the nerve being near enough the surface to be influenced by varying degrees of temperature); to focal infection; or to pressure within the pelvis, as occasioned by a pelvic growth; by an inflammatory deposit; by an aneurysm of one of the branches of the internal iliac; by a sciatic hernia; by the descent of the fetal head; by an impaction of feces; in fact, by any form of pressure. Cases of obstinate sciatica, not yielding to the ordinary remedies, may call for operative interference in the shape of stretching and injecting the nerve. The incision for exposing the nerve is made in a line drawn downward from a point just medial to the midpoint between the tuberosity of the ischium and the greater trochanter, to the center of the popliteal space. It may be stretched either at the fold of the buttock or in the middle of the thigh.

The **small sciatic nerve** (**posterior cutaneous nerve of thigh**) arises from the anterior branches of the second and third sacral nerves. It leaves the pelvis through the great sacro-sciatic (*greater sciatic*) foramen below the pyriformis muscle. In this locality the inferior gluteal nerve is generally adherent to it. It runs along the medial side of the great sciatic (*sciatic*) nerve, accompanied by the sciatic (*inferior gluteal*) artery. It descends beneath the gluteus maximus, at the inferior border of which it comes in immediate relation with the deep fascia, and continues down the back of the thigh, beneath this fascia, to the upper part of the calf, where it becomes subcutaneous. In the calf it

accompanies the short (*small*) saphenous vein to the middle of the leg, where its terminal filaments communicate with the short saphenous (*sural*) nerve. In the proximal part of its course it is frequently accompanied by branches of the sciatic (*inferior gluteal*) artery (cutaneous branches), which anastomose with branches of the perforating arteries of the profunda femoris. Occasionally, they accompany the nerve to the knee.

The branches of the small sciatic (*posterior cutaneous nerve of thigh*) are cutaneous and muscular.

The *muscular branches* enter the under surface of the gluteus maximus near its inferior border. These are really the fibers of the inferior gluteal adherent to the small sciatic (*posterior cutaneous nerve of thigh*). The *cutaneous branches* are divided into ascending and medial. The ascending branches turn upward around the inferior border of the gluteus maximus and are distributed to the skin and fascia covering its lower third; the medial branches are distributed to the skin and fascia of the upper and medial side of the thigh posteriorly.

The **inferior pudendal (long perineal) nerve,** or *nerve of Sœmmering,* the largest of the medial cutaneous branches of the small sciatic nerve (*posterior cutaneous nerve of thigh*), passes medialward below the tuberosity of the ischium, pierces the deep fascia, and is distributed to the perineum and scrotum in the male, and to the labium in the female. It is described with the perineum.

Pain in the scrotum or labium may be due to pressure upon the trunk of the inferior pudendal (*long perineal*) nerve or upon the small sciatic (*posterior cutaneous nerve of thigh*), or upon that portion of the sacral plexus or spinal cord from which the filaments arise; while, on the other hand, pressure upon the terminal part of the inferior pudendal (*long perineal*) may give rise to pain referred to the back of the thigh, by referring the pain to the end-fibers of the small sciatic nerve (*posterior cutaneous nerve of thigh*).

The **inferior gluteal nerve** arises from the second and third sacral nerves. It passes out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen below the pyriformis muscle, and enters the under surface of the gluteus maximus muscle, which it supplies. In the foramen it is often adherent to the small sciatic nerve (*posterior cutaneous nerve of thigh*).

By displacing the great sciatic (*sciatic*) nerve lateralward the nerve to the obturator internus and the nerve to the quadratus femoris can be seen.

The **nerve to the obturator internus muscle** arises from the second and third sacral nerves. It passes out of the pelvis through the great sacro-sciatic (*greater sciatic*) foramen below the pyriformis and crosses the base of the ischial spine on the lateral side of the pudendal vessels and nerve. It gives off a branch to the

superior gemellus and enters the lesser sacro-sciatic (*lesser sciatic*) foramen to supply the obturator internus.

The **nerve to the quadratus femoris muscle** arises from the third sacral nerve. It is often adherent to the under surface of the great sciatic (*sciatic*) nerve. It passes under the tendon of the obturator internus muscle and the gemelli muscles. It supplies the inferior gemellus, the quadratus femoris, and the hip-joint.

The **sciatic (inferior gluteal) artery,** the larger of the two terminal branches of the anterior trunk of the internal iliac (*hypogastric*), emerges from the pelvis through the great sacro-sciatic (*greater sciatic*) foramen below the pyriformis muscle. It descends in the interval between the tuberosity of the ischium and the greater trochanter in company with the great sciatic (*sciatic*) nerve and passes over the superior gemellus, the tendon of the obturator internus, the inferior gemellus, the quadratus femoris, and the upper part of the adductor magnus. It terminates in the descending branch which accompanies the small sciatic nerve (*posterior cutaneous nerve of thigh*) and anastomoses with the superior perforating and with the external (*lateral*) and the internal (*medial*) circumflex arteries. Occasionally, this artery may be double, and may give origin to the femoral artery, which then passes down the back of the thigh to the popliteal space.

The branches given off from the artery outside the pelvis are: the coccygeal, inferior gluteal, comitans nervi ischiadici, muscular, articular, cutaneous, and anastomotic.

The *coccygeal branch* perforates the great sacro-sciatic (*sacro-tuberous*) ligament and supplies the gluteus maximus and the structures on the back of the sacrum and coccyx. It anastomoses with its fellow of the opposite side. The inferior gluteal enters the under surface of the gluteus maximus with the inferior gluteal nerve.

The *comitans nervi ischiadici* accompanies the great sciatic (*sciatic*) nerve and finally enters its substance.

The *muscular branches* supply the muscles behind the hip-joint.

The *articular branches* are distributed to the capsule of the hip-joint.

The *cutaneous branches* accompany the cutaneous branches of the small sciatic nerve (*posterior cutaneous nerve of thigh*) and supply the integument of the lower portion of the gluteal region.

The *anastomotic branches* pass lateralward over the quadratus femoris to the trochanteric fossa, anastomosing with the internal (*medial*) and external (*lateral*) circumflex and the superior perforating arteries, thus establishing the *crucial anastomosis*. The sciatic (*inferior gluteal*) artery also anastomoses with the obturator and the gluteal (*superior gluteal*) arteries, and forms an important part

of the collateral circulation after ligation of the femoral, the common iliac, or the external iliac arteries.

Ligation of the Sciatic (Inferior Gluteal) Artery (Plate CCCVI).—The artery can be ligated in the buttock through an incision carried in a line drawn from the posterior superior spine of the ilium to the lateral side of the ischial tuberosity. The junction of the proximal with the intermediate third of this line marks the point of exit of the artery through the greater sacro-sciatic (*greater sciatic*) foramen, and should correspond to the center of the incision.

The **internal pudendal artery,** the smaller of the two terminal branches of the anterior trunk of the internal iliac (*hypogastric*), emerges from the pelvis through the greater sacro-sciatic (*greater sciatic*) foramen below the pyriformis muscle. It lies medial to the sciatic (*inferior gluteal*) artery, and as it winds over the spine of the ischium and passes into the pelvis through the lesser sacro-sciatic (*smaller sciatic*) foramen, the venæ comites lie on either side, the pudendal nerve lies medial to it, and the nerve to the obturator internus to its lateral side. For further description of its course see the description of the perineum. Hemorrhage from the internal pudendal artery may be arrested by compressing the vessel against the spine of the ischium. Like the gluteal (*superior gluteal*) and sciatic (*inferior gluteal*) arteries, it can be ligated in the buttock through an incision somewhat similar to that for the ligation of the sciatic (*inferior gluteal*), except that the center of the incision should correspond to the junction of the intermediate with the distal third of the line, which is the point of entrance of the internal pudendal artery into the lesser sacro-sciatic (*smaller sciatic*) foramen. It gives off a few branches to the gluteus maximus and the obturator internus muscles, and a sacral branch which pierces the great sacro-sciatic (*sacro-tuberous*) ligament and anastomoses with the sciatic (*inferior gluteal*) artery.

The Sciatic (Inferior Gluteal) and Internal Pudendal Veins.—The sciatic (*inferior gluteal*) and internal pudendal arteries are accompanied by veins receiving branches corresponding to those of the arteries, and, by their union within the pelvis, form the anterior trunk of the internal iliac (*hypogastric*) vein.

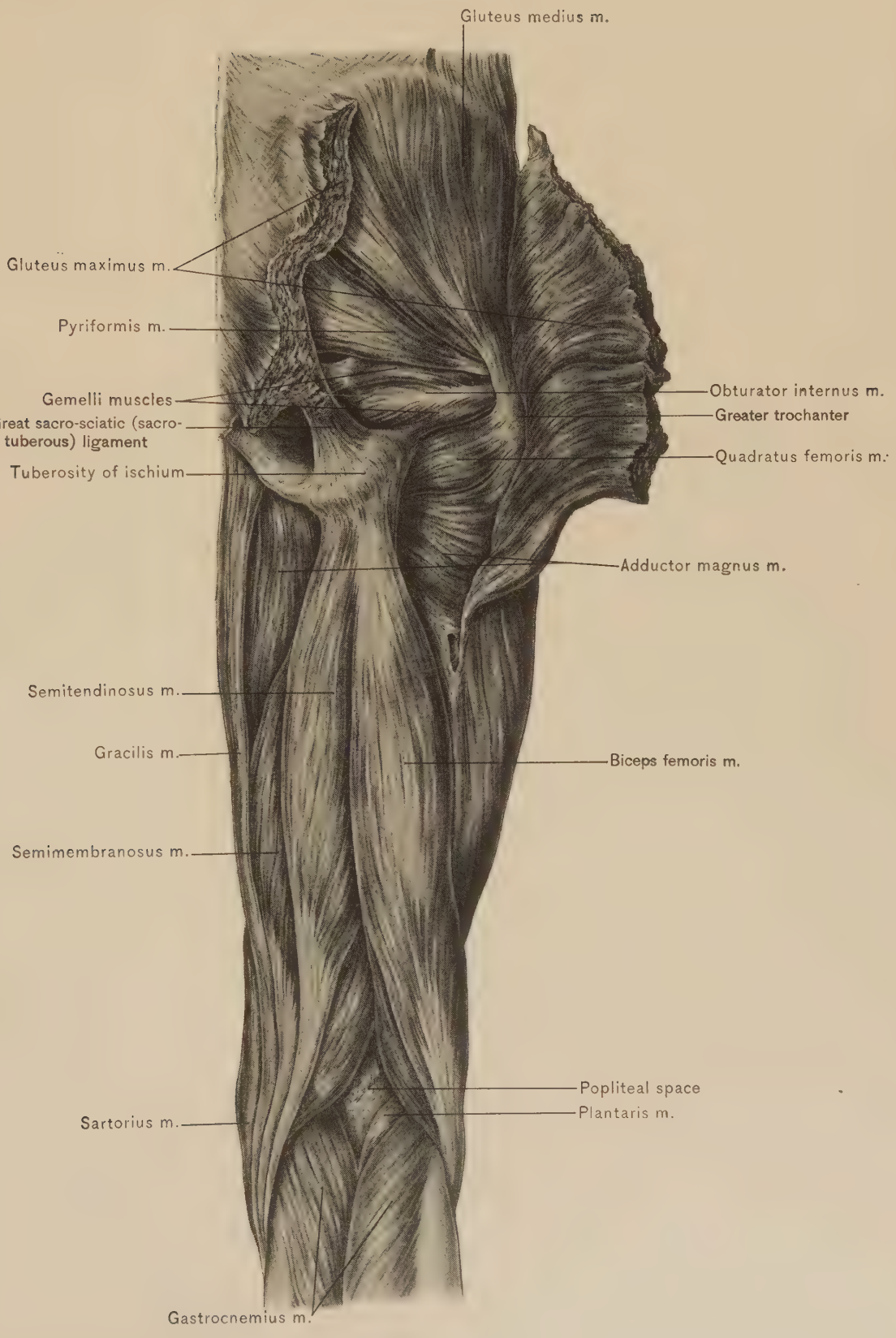
The **pudendal nerve,** a branch of the sacral plexus, arises from the second, third, and fourth sacral nerves. It leaves the pelvis through the great sacro-sciatic (*greater sciatic*) foramen, below the pyriformis muscle. Accompanying the internal pudendal artery, but lying to its medial side, it runs over the spine of the ischium near the attachment of the lesser sacro-sciatic (*sacro-spinous*) ligament, and enters the pelvis through the lesser sacro-sciatic (*smaller sciatic*) foramen.

Dissection.—To study the remaining muscles of the gluteal region, the great sciatic (*sciatic*) nerve should be displaced laterally and, if necessary, the branches of the sciatic (*inferior gluteal*) artery cut away (Plate CCCVII).

Sciatic (inferior gluteal) a.
Pyriformis m.
Small sciatic (posterior femoral cutaneous) n
Fibers of gluteus maximus m., separated
Great sciatic (sciatic) n.

LIGATION OF SCIATIC (INFERIOR GLUTEAL) ARTERY AT ITS POINT OF EXIT AND EXPOSURE OF SCIATIC NERVE.

PLATE CCCVII.



MUSCLES OF THE BUTTOCK AND FLEXOR MUSCLES OF THE KNEE.

The **gemelli muscles,** superior and inferior, are accessory to the obturator internus, and are situated one above, and the other below the tendon of that muscle. The *gemellus superior muscle,* the smaller of the two, *arises* from the lateral surface of the spine of the ischium and is *inserted* into the superior border of the tendon of the obturator internus muscle. It is sometimes absent. The *gemellus inferior muscle arises* from the superior part and gluteal surface of the tuberosity of the ischium and is *inserted* with the tendon of the obturator internus muscle into the greater trochanter.

Nerve Supply.—The branch to the gemellus superior is derived from the nerve to the obturator internus; that to the gemellus inferior from the nerve to the quadratus femoris.

The **obturator internus muscle** *arises* within the pelvis from the body and the descending ramus of the pubis, the ascending (*superior*) ramus of the ischium, and the bone between the foramen and the great sacro-sciatic (*greater sciatic*) notch, the medial surface of the obturator membrane, and from the obturator fascia, which covers the muscle. The fibers are directed backward and lateralward and terminate in four tendinous bands found on the deep surface of the muscle. It leaves the pelvis through the lesser sacro-sciatic (*smaller sciatic*) foramen. The four bands unite to form a single tendon which is *inserted* into the medial surface of the greater trochanter at its superior part, in front of the pyriformis. The four bands pass over the medial surface of the tuberosity of the ischium, which is covered with cartilage and a large synovial bursa. Within the pelvis it is in relation laterally with the obturator membrane and the innominate bone; medially with the obturator fascia, the levator ani muscle, the pelvic viscera, and the pudendal vessels and nerve; above with the obturator vessels and nerve. Outside the pelvis the tendon of the obturator internus muscle and the gemelli muscles are in relation, above, with the pyriformis muscle and the great sciatic (*sciatic*), and the small sciatic (*posterior cutaneous nerve of thigh*) nerves and the sciatic (*inferior gluteal*) vessels; below with the quadratus femoris muscle and branches of the internal (*medial*) circumflex artery; in front of them lie the capsule of the hip-joint and the tendon of the obturator externus muscle, and they are covered behind by the gluteus maximus muscle, the sciatic (*inferior gluteal*) vessels and sciatic nerves (*sciatic nerve and posterior cutaneous nerve of thigh*), and the great sacro-sciatic (*sacro-tuberous*) ligament.

Nerve Supply.—The nerve supplying this muscle is a branch of the second and third sacral nerves, and leaves the pelvis through the great sacro-sciatic (*greater sciatic*) foramen, passes over the spine of the ischium, and then enters the pelvis through the lesser sciatic foramen to reach the under surface of the muscle.

Action.—The action of the obturator internus, with the gemelli, is to rotate the thigh lateralward; when the hip-joint is flexed, these muscles assist slightly in abduction.

The **quadratus femoris muscle** is situated between the gemellus inferior and the superior border of the adductor magnus. It *arises* from the superior border of the lateral surface of the tuberosity of the ischium and passes horizontally lateralward to be *inserted* into the superior part of the linea quadrati, a line running downward from the posterior intertrochanteric line. Between the inferior border of the quadratus femoris and the superior border of the adductor magnus emerges the terminal branch of the internal (*medial*) circumflex artery. Between it and the lesser trochanter is a small synovial bursa. In front are the obturator externus muscle and branches of the internal (*medial*) circumflex artery; above it is the inferior gemellus, and below it, the adductor magnus muscle. Behind it are the gluteus maximus muscle and the sciatic (*inferior gluteal*) vessel and sciatic nerves (*sciatic nerve and posterior cutaneous nerve of thigh*).

Nerve Supply.—Through a branch of the sacral plexus, which passes beneath the gemelli and the tendon of the obturator internus muscle to enter its under surface.

Action.—To assist in the abduction and lateral rotation of the thigh.

Dissection.—Divide and reflect the quadratus femoris, and expose the obturator externus.

The **obturator externus muscle** *arises* from the descending (*inferior*) ramus of the pubes, the ascending (*superior*) ramus of the ischium, the medial two-thirds of the lateral surface of the obturator membrane, and from the tendinous arch over the obturator vessels. The fibers pass backward and lateralward and terminate in a tendon which runs across the back of the hip-joint and is *inserted* into the trochanteric fossa on the medial surface of the greater trochanter. In front of it are the psoas, pectineus, and adductor brevis muscles; behind it, the quadratus femoris muscle and the obturator vessels; above it, the obturator vessels and nerve and the capsule of the hip-joint. Behind it are the obturator membrane and the innominate bone.

Nerve Supply.—From the posterior division of the obturator, which enters the inferior surface of the muscle.

Action.—It is a lateral rotator of the thigh.

THE POPLITEAL SPACE

Dissection.—This part of the body should be dissected before the back of the thigh, as otherwise the boundaries would be more or less disturbed. The

limb should remain in the same position as for the dissection of the buttock. Carry a vertical incision through the center of the space and at each extremity make a transverse incision, so that the end-result is the letter H. The skin is then dissected up in two flaps, care being taken not to remove the cutaneous branches of the small sciatic nerve (*posterior cutaneous nerve of thigh*).

The **Popliteal Space** is the hollow behind the knee, and is seen to the best advantage when the leg is very slightly flexed upon the thigh. With the leg in the extended position, the hollow is replaced by the rounded prominence of the condyloid extremity of the femur carrying in advance of it the overlying soft parts.

The skin of this region is thinner and not so movable as that covering the front of the knee. If destroyed either by injury or burns or extensive ulceration, the resulting cicatrix may contract to such an extent as to cause marked and permanent flexion of the knee. This can be guarded against by keeping the leg extended during the process of healing and by wearing an apparatus which will maintain the limb in the straight position. The skin here may be ruptured by forcible extension applied to the knee in cases of contraction.

In the superficial fascia are seen cutaneous branches of the small sciatic (*posterior cutaneous nerve of thigh*) and internal (*medial*) cutaneous nerves, the terminal part of the small (*short*) saphenous vein, and a number of superficial lymph glands. These glands are liable to undergo enlargement and suppuration after injuries to the foot and leg.

Dissection.—Reflect the superficial fascia by making incisions similar to those made in reflecting the skin. This will bring into view the popliteal fascia.

The **popliteal fascia** is continuous with the fascia lata and the deep fascia of the leg. It forms the roof of the popliteal space; it is attached to the bony prominences of the knee, and is connected laterally with the sheaths of the tendons and muscles bounding the space. Strong transverse bands connecting the tendons are stretched across the space and render the fascia very tense. Its strength and power of resistance complicate the diagnosis of tumors in this space and limit the progress of a popliteal abscess toward the surface. The very severe pain associated with tumors and collections of pus in this space is also caused by the unyielding character of the fascia. A popliteal abscess unable to reach the surface may extend either upward into the thigh or downward into the leg. This space may hold a very considerable quantity of pus, although the swelling may be slight; the abscess may ulcerate into the popliteal artery, or the pus, if unable to find a way to escape, may ultimately enter the knee-joint (Treves). Pus can reach the space from the buttock or from the pelvis, by following the great sciatic (*sciatic*) nerve; or it may extend from the thigh through the opening in the adductor magnus muscle for the femoral vessels. This fascia

is pierced by the short (*small*) saphenous vein and the small sciatic nerve (*posterior cutaneous nerve of thigh*).

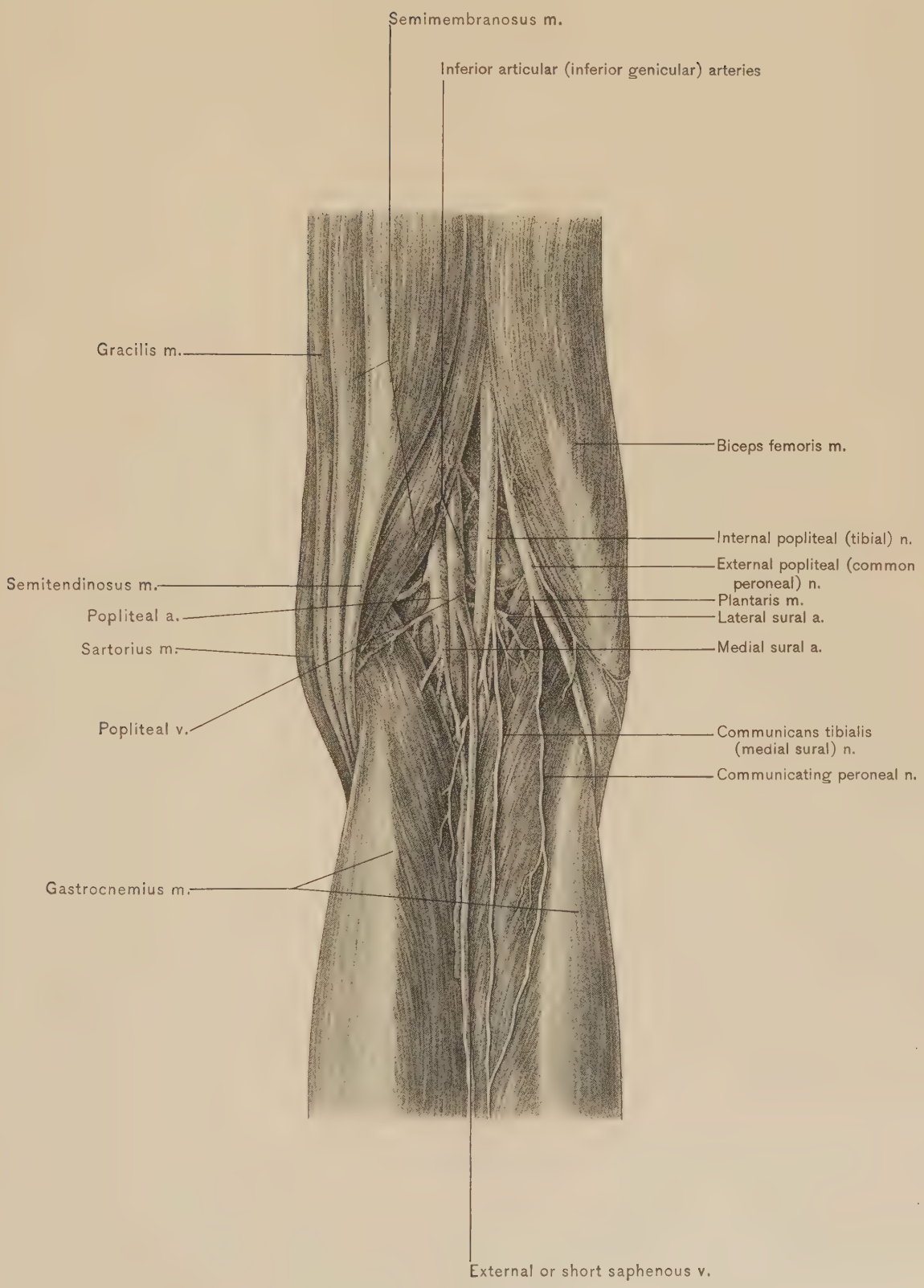
Dissection.—Reflect the fascia, care being taken not to injure the short (*small*) saphenous vein and the small sciatic nerve (*posterior cutaneous nerve of thigh*). This opens up the popliteal space.

The **popliteal space,** or **fossa** (Plate CCCVIII), is diamond-shaped, being widest immediately behind the knee, and deepest above the articular end of the femur. It is bounded, laterally and above, by the tendon of the biceps femoris muscle; medially and above, by the tendons of the semitendinosus and semimembranosus, gracilis, and sartorius muscles; laterally and below, by the lateral head of the gastrocnemius and the plantaris muscles; medially and below, by the medial head of the gastrocnemius muscle. Its floor, from above downward, is formed by the posterior surface of the distal third of the shaft of the femur included between the two condyloid ridges, by the posterior (*oblique popliteal*) ligament of the knee-joint, and by the popliteus muscle. Its roof, already described, is formed by the popliteal fascia. It contains: the popliteal artery and its branches, the popliteal vein and its tributaries, the articular branch of the obturator nerve to the knee-joint, the internal popliteal (*tibial*) and external popliteal (*common peroneal*) nerves and their branches, the small sciatic nerve (*posterior cutaneous nerve of thigh*), the terminal part of the short (*small*) saphenous vein on its way to enter the popliteal, lymph glands, and a quantity of adipose and cellular tissue continuous with that surrounding the muscles of the back of the thigh and calf. The fact that the connective and adipose tissues of this space are continuous with the tissue surrounding the adjacent muscles explains why collections of pus in the space are liable to extend into the thigh or the leg.

Dissection.—The contents of the space and their relations should now be carefully examined, the fat being removed as the dissection is carried on.

The **internal popliteal** (**tibial**) **nerve,** the larger of the two terminal divisions of the great sciatic (*sciatic*), runs through the middle of the popliteal space. It lies superficial to the popliteal vein and artery, crosses these vessels from without medialward, and terminates at the lower border of the popliteus muscle where it passes with the popliteal artery under the arch of the soleus. The relations of the internal popliteal (*tibial*) nerve, the popliteal vein, and the popliteal artery vary in the proximal, intermediate, and distal portions of the space, but the relation throughout the space from the surface inward, or in the order of the dissection, is the same in all portions, and is: nerve, vein, artery. In the most proximal portion of the space both the nerve and the vein lie lateral to the artery; in the intermediate portion they lie directly over the artery; and in the most distal portion the nerve and vein lie medial to the artery, the nerve being the more medial.

PLATE CCCVIII.



POPLITEAL SPACE.

The branches of the internal popliteal (*tibial*) nerve are the articular, muscular, and cutaneous.

The *articular branches*, three in number, pierce the back of the capsule of the knee-joint. They accompany the superior, internal, and external articular (*medial and lateral genicular*) arteries and the azygos (*middle genicular*) artery.

The *muscular branches*, four or five in number, supply the two heads of the gastrocnemius, the plantaris, the soleus, and the popliteus muscles.

The *cutaneous* (*medial sural*) *branch*, also called the *communicans tibialis nerve*, descends in the groove between the two heads of the gastrocnemius muscle, and pierces the deep fascia of the leg about the middle of the calf, where it is joined by a branch (communicans peronei) of the external popliteal (*common peroneal*) nerve, to form the short saphenous (*sural*) nerve.

The **external popliteal** (**common peroneal**) **nerve**, the remaining terminal division of the great sciatic (*sciatic*), passes along the lateral border of the popliteal space close to the medial side of the tendon of the biceps femoris. It leaves the space by passing below the bicipital tendon and winds around the fibula about two and a half centimeters (one inch) below its head, where it pierces the peroneus longus muscle and divides into its two terminal branches, the anterior tibial (*deep peroneal*) and the musculo-cutaneous (*superficial peroneal*) nerves.

The branches of the external popliteal (*common peroneal*) nerve are articular and cutaneous (*sural*).

The *articular branches*, two in number, accompany the superior and inferior external articular (*superior and inferior genicular*) arteries to the lateral side of the knee; a recurrent articular branch, which runs with the recurrent tibial artery through the tibialis anterior muscle to the front of the knee, is given off from the external popliteal (*common peroneal*) nerve, where it divides.

The *cutaneous* (*sural*) *branches*, two or three in number, supply the skin and fascia along the posterior and lateral aspect of the leg as far as the intermediate third. The communicans fibularis (*peroneal anastomotic*) branch, the largest cutaneous branch, arises near the head of the fibula, crosses the lateral head of the gastrocnemius muscle, and reaching the middle of the leg, joins the communicans poplitei (*medial sural*) nerve to form the short saphenous (*sural*) nerve. In some cases the communicans fibularis (*communicans peronei*) continues as a separate branch as far as the heel.

Dissection.—Remove the fat occupying the deep part of the space, with its four or five lymph glands, and expose the popliteal vessels and their branches.

Popliteal lymph glands: it is important to note that one of the lymph glands generally lies on the popliteal artery, and, when enlarged, gives rise to a pulsating tumor which may be mistaken for an aneurysm.

The **popliteal artery,** the continuation of the superficial femoral (*femoral*), commences at the opening in the adductor magnus muscle and passes through the middle of the popliteal space to the distal border of the popliteus muscle, where it ends by dividing into its two terminal branches: the anterior and posterior tibial arteries. It rests, from above downward, on the posterior surface of the distal third of the femur, upon the posterior (*oblique popliteal*) ligament of the knee-joint, and upon the fascia covering the popliteus muscle. In the proximal part of the space the popliteal artery is concealed by the lateral margin of the semimembranosus muscle, and in the distal part, by the medial head of the gastrocnemius muscle and the plantaris and the soleus muscles. Occasionally, the popliteal artery divides into its terminal branches opposite the knee-joint. The artery sometimes divides into the anterior tibial and the peroneal arteries, the posterior tibial artery being either wanting or very small. Very occasionally, the popliteal artery divides into three branches; the anterior and posterior tibial and the peroneal.

The branches of the popliteal artery are the articular (*genicular*), which are given off from the vessel at right angles, the muscular, and the cutaneous.

The *articular* (*genicular*) *branches* are the superior lateral and medial, the inferior lateral and medial, and the azygos articular.

The *superior articular* (*genicular*)*arteries* arise from the popliteal, one on each side above the condyles of the femur, pass almost transversely beneath the hamstring muscles, and wind round the femur to reach the front of the knee-joint. The *superior lateral articular* (*lateral superior genicular*) *artery* passes beneath the tendons of the biceps femoris, pierces the lateral intermuscular septum, and divides into two branches: a superficial and a deep. The superficial branch anastomoses with the descending branch of the external (*lateral*) circumflex artery and supplies the vastus externus (*vastus lateralis*) muscle; the deep branch forms an arch across the femur with the anastomotica magna artery (*arteria genu suprema*) and supplies the lower part of the femur and the knee-joint. The *superior medial articular* (*medial superior genicular*) *artery* passes beneath the tendon of the adductor magnus and divides into two branches, one of which supplies the vastus medialis and anastomoses with the anastomotica magna (*genu suprema*) and inferior internal articular (*medial inferior genicular*) arteries; the other branch anastomoses with the superior external articular (*lateral superior genicular*) artery and supplies the knee-joint.

The *inferior articular* (*inferior genicular*) *arteries* arise beneath the heads of the gastrocnemius muscle and wind round the head of the tibia to reach the front of the knee-joint. The *inferior external articular* (*lateral inferior genicular*) *artery* passes beneath the tendon of the biceps, above the head of the fibula, to

the front of the knee and anastomoses with the inferior internal articular (*medial inferior genicular*), the superior external articular (*lateral superior genicular*), and the recurrent tibial arteries. The *inferior internal articular* (*medial inferior genicular*) *artery* passes beneath the internal lateral (*tibial collateral*) ligament, below the medial tuberosity (*medial condyle*) of the tibia, and ascends to the front and medial side of the knee-joint, anastomosing with the superior internal articular (*medial superior genicular*) and the inferior external articular (*lateral inferior genicular*) arteries.

The *azygos articular* (*middle genicular*) *artery* pierces the posterior (*oblique popliteal*) ligament of the knee-joint and supplies the ligamentous structures, the fat, and the synovial membrane in the interior of the joint.

The *muscular branches* consist of an upper and a lower set. The upper set supplies the vastus externus (*vastus lateralis*), the semimembranosus, and the biceps femoris muscles, and anastomoses with the lower perforating branches of the profunda femoris artery. The lower set, *the sural arteries*, are two large branches distributed to the heads of the gastrocnemius, the plantaris, and the soleus muscles.

The *cutaneous branches*, usually three in number, arise from the popliteal or its branches and supply the skin of the back of the leg.

The **popliteal vein** is intimately associated with the artery. In the proximal portion of the space, it lies superficial and lateral to the artery; in the middle portion it lies superficial to and over, and in the distal portion, superficial and medial to the artery. It commences at the distal border of the popliteus muscle by the union of the companion veins of the anterior and posterior tibial arteries and ends at the opening in the adductor magnus muscle, beyond which it is continued as the superficial femoral vein. Into it empty the short (*small*) saphenous vein and the venæ comites of the branches of the popliteal artery.

Between the popliteal artery and the popliteal vein is the **articular branch of the obturator nerve** which pierces the posterior (*oblique popliteal*) ligament of the knee-joint to be distributed to the synovial membrane; it enters the popliteal space by piercing the adductor magnus muscle.

The Surgery of the Popliteal Vessels.—When its inner and middle coats are diseased, in the living subject, the popliteal artery may be injured by violent flexion and extension of the leg. The inner coat is the one most likely to be ruptured. Its rupture is soon followed by dilatation of the remaining coats, and by aneurysm. By strongly flexing and extending the leg in the cadaver, the inner and middle coats of the artery can be ruptured.

Aneurysm of the popliteal artery is more common than of any other vessel in the body, except the thoracic aorta. The reason for this is that, owing to the

position the artery holds with relation to the knee-joint, it is constantly being subjected to more or less violent motion. A popliteal aneurysm may burst into the knee-joint, extravasate into the popliteal space, and burrow up the thigh or down the leg.

The relation of the artery to the vein and internal popliteal (*tibial*) nerve explains why, in an aneurysm of any size, both the leg and foot are swollen and accompanied by numbness or pain.

From the relation the popliteal artery bears to the distal third of the femur, the vessel may be injured in fracture of this portion of the bone. After reduction of such a fracture, it is good practice to maintain the limb with the knee in the slightly flexed position for a few days at least, to avoid the possibility of rupture resulting from strong extension applied immediately to the leg. Should the limb, however, be placed in the extended position from the start, the force of the circulation, as shown by the pulsation in the dorsalis pedis and posterior tibial arteries, should be carefully noted from time to time, and compared with that of the sound side.

The popliteal vessels, being very deep, are seldom wounded. The distal part of the artery may be reached from the anterior aspect of the leg by passing an instrument between the tibia and the fibula. Spence reports the case of a farmer who received a wound in the front of the leg just below the knee from the slipping of his knife while cutting a stick. The knife entered the interosseous space and wounded the popliteal artery at its bifurcation, nearly severing the anterior tibial artery from the main trunk.

The position of the limb most favorable for the examination of the popliteal space, as has already been noted, is with the knee-joint partly flexed. The popliteal artery is much curved except when the leg is extended; unlike many of the other large vessels, it is not supported by strong muscles, but is surrounded simply by fat and areolar tissue. By strongly flexing the knee, the lumen of the popliteal artery is directly affected and the pulsation in the anterior and posterior tibial arteries, as felt in front of the ankle and behind the medial malleolus, is materially weakened.

Ligation of the popliteal artery, except for a wound of the vessel, is never performed. In popliteal aneurysm the superficial femoral artery is tied at its point of election. The popliteal artery can be exposed in the proximal portion of the popliteal space by one of two incisions: through the roof and through the medial side of the space. In reaching the artery by the latter method the incision is carried along the tendon of the adductor magnus muscle or the posterior border of the distal third of the femur, dividing the skin, the superficial fascia, and deep fascia, and exposing the sartorius muscle. This muscle is then displaced down-

ward, thus opening up the interval bounded in front by the femur, the tendon of the adductor magnus, and the vastus internus (*vastus medialis*) muscle, and behind by the displaced sartorius, the gracilis, and the semimembranosus muscles. Through this interval the finger can be carried into the popliteal space and the pulsation of the vessel felt. In dividing the superficial fascia the long (*great*) saphenous vein should be avoided; after the sartorius has been displaced, the long saphenous (*saphenous*) nerve may be seen passing beneath it.

The popliteal vein is a remarkably strong vessel with dense thick walls, and resembles an artery in showing little tendency to collapse when divided in an amputation of the knee-joint. It is very rarely ruptured by violence, in spite of the fact that it lies more superficial than the artery; as a rule, the artery alone is torn. The popliteal vein and artery are very adherent to each other, as is readily seen when attempting to separate them before passing the ligature, when ligating the artery.

A *popliteal abscess* may be evacuated by making an incision through either the roof of the space or above the tendon of the biceps femoris, between it and the ilio-tibial band, or tract. In either case, if the collection is not at once reached, further exploration should be made with the finger or with a grooved director.

The *bursæ* in relation with the lateral boundaries of the popliteal space, usually six in number, are situated two on the medial, and four on the lateral side. Of the two on the medial side of the space, one is between the medial condyle of the femur and the medial head of the gastrocnemius and the semimembranosus, and one between the medial tuberosity (*medial condyle*) of the tibia and the tendon of the semimembranosus. The bursa between the medial condyle of the femur and the medial head of the gastrocnemius and semimembranosus is the largest bursa in relation with the popliteal space, and the one most often enlarged. In the majority of cases it communicates with the knee-joint in adult life. By extending the leg under such conditions the bursa is rendered tense, while with the leg flexed it becomes relaxed and may entirely disappear by emptying its contents into the joint. The small bursa between the medial tuberosity (*medial condyle*) of the tibia and the tendon of the semimimembranosus seldom, if ever, communicates with the knee-joint, although it may communicate with the large bursa over the medial condyle. Of the four bursæ on the lateral side of the popliteal space, one is between the tendon of the popliteus muscle and the external lateral (*fibular collateral*) ligament of the knee, one between the tendon of the popliteus and the lateral tuberosity (*lateral condyle*) of the tibia (and is an extension of the synovial membrane of the knee), one between the lateral head of the gastrocnemius and the lateral condyle of the femur, and one between the tendon of the biceps femoris and the external lateral (*fibular collateral*) liga-

ment of the knee, over which runs the external popliteal (*common peroneal*) nerve. It is readily understood how wounds of any of these bursæ may be mistaken for wounds of the knee-joint, by thinking that the escaping bursal fluid is synovial. Enlargement of the bursa over which runs the external popliteal (*common peroneal*) nerve may produce sufficient pressure to cause pain to be referred to the line of distribution of its branches, or even paralysis of the muscles supplied by it. In the diagnosis of the surgical affections of the popliteal space, as well as of the knee-joint, the presence of these bursæ must not be lost sight of, as both acute and chronic inflammation of one or more of them will often figure in the differential diagnosis.

In certain cases of contracted knee, division of the *hamstring tendons*, either alone or in connection with the popliteal fascia, is called for. When division of the tendons suffices, it is best done subcutaneously. In dividing the tendon of the biceps femoris subcutaneously, care is required not to cut the external popliteal (*common peroneal*) nerve; this nerve is in greater danger of being wounded, however, when resecting the head of the fibula. With the leg extended, the tendon is brought nearer the surface and the distance between it and the nerve increased. If it becomes necessary to divide both the popliteal fascia and the tendons, the open operation is the safer.

THE BACK OF THE THIGH

Dissection.—The dissection of the popliteal space having been completed, that of the back of the thigh, extending from the gluteal fold to the popliteal space, should next be made. Carry a longitudinal incision through the integument intervening between the gluteal region and the popliteal space, connecting the one made in the dissection of the former with that made in the dissection of the latter, and reflect it to either side.

The superficial fascia is rich in fat, and upon the lateral aspect of the limb it contains cutaneous branches of the posterior division of the external cutaneous nerve (*lateral cutaneous nerve of thigh*); in the middle line of the limb, cutaneous branches of the small sciatic nerve (*posterior cutaneous nerve of thigh*) and, on the medial aspect of the thigh, branches of the internal cutaneous (*medial cutaneous*) and obturator nerves.

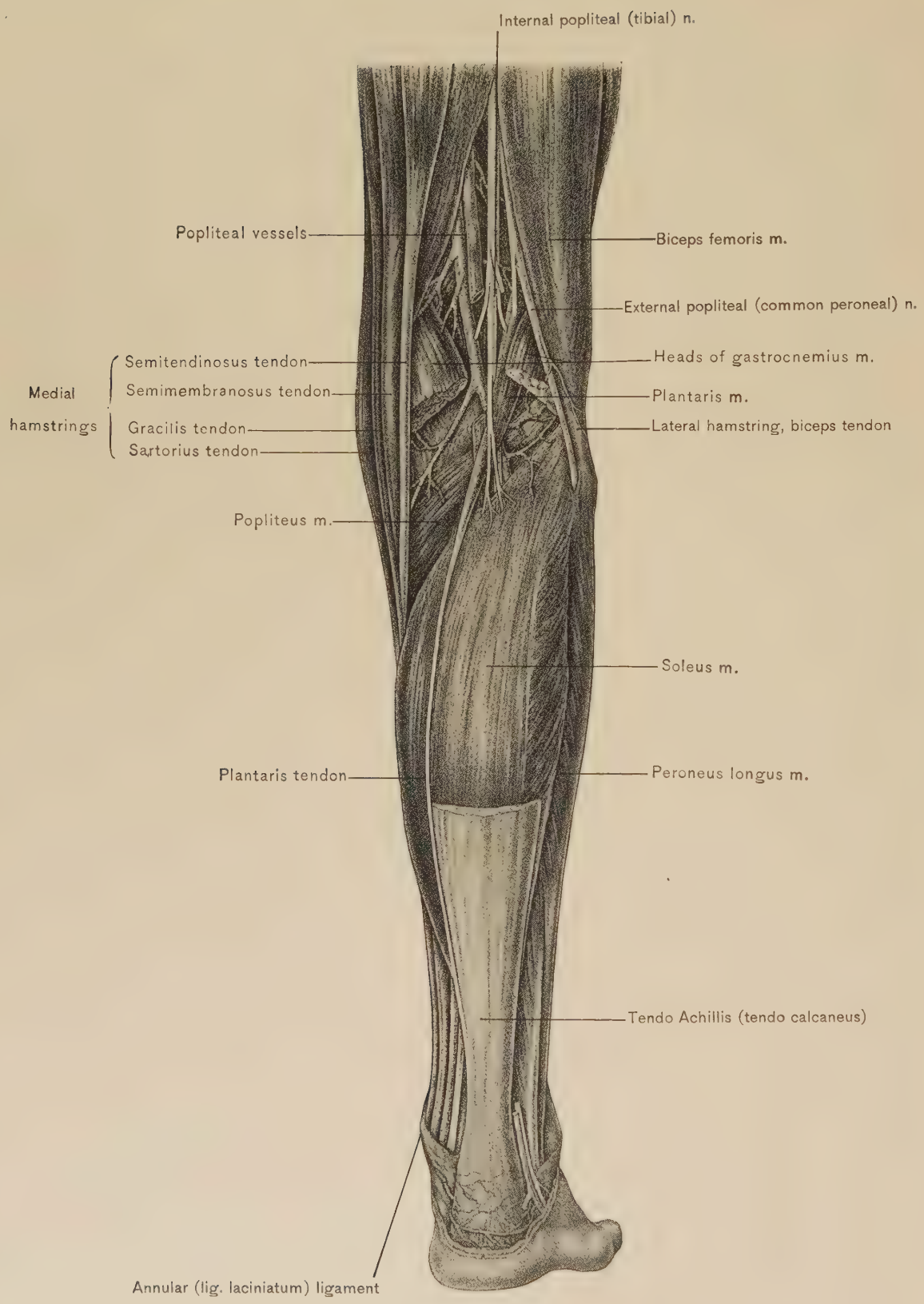
The veins occupying the superficial fascia are very small.

Dissection.—Reflect the superficial fascia by an incision similar to that made in the skin and expose the deep fascia.

The fibers of the deep fascia run chiefly in a transverse direction; the fascia becomes stronger near the popliteal space, where it forms the popliteal fascia.

Remove the deep fascia in the same way as the superficial, being careful not to destroy the small sciatic nerve (*posterior cutaneous nerve of thigh*) and the ter-

PLATE CCCIX.



SOLEUS AND PLANTARIS MUSCLES.

minal branch of the sciatic (*inferior gluteal*) artery. These will now be exposed, together with the flexor muscles of the thigh, the great sciatic (*sciatic*) nerve and its terminal divisions, and the perforating branches of the deep femoral (*profunda femoris*) artery; all of these structures should be carefully cleaned and their relations noted.

The *small sciatic nerve* (*posterior cutaneous nerve of thigh*) and *sciatic* (*inferior gluteal*) *artery* have been described with the gluteal region.

The flexor group of muscles, known as the **hamstrings** (Plate CCCIX), extends from the pelvis to the leg, passing behind the hip-joint and the knee-joint. This group comprises the biceps, the semitendinosus, and the semimembranosus muscles; they all arise by strong tendons from the tuberosity of the ischium. The divergence of these muscles below forms the proximal end of the popliteal space.

The **biceps femoris** is situated on the lateral side of the thigh, and arises by a long and a short head. The *long head arises* by a strong tendon from an impression on the back of the tuberosity of the ischium in common with the semitendinosus muscle; the *short head arises* by fleshy fibers from the lateral division of the linea aspera between the adductor magnus and vastus lateralis muscles, and from the lateral intermuscular septum of the deep fascia; this head extends from just below the insertion of the gluteus maximus downward to within a short distance of the condyle. The fibers of the short head join those of the long head, and form a common tendon which is *inserted* into the lateral side of the head of the fibula. At its insertion the tendon divides into two portions which embrace the external lateral (*fibular collateral*) ligament of the knee-joint, and gives off a strong expansion which extends forward to the lateral tuberosity (*lateral condyle*) of the tibia and becomes continuous with the fascia of the leg.

Nerve Supply.—From the great sciatic (*sciatic*) nerve.

Action.—The biceps femoris is a flexor of the knee and lateral rotator of the leg. Taking its fixed point from below, it acts upon the hip-joint. It is superficial, except where it is covered by the gluteus maximus.

The **semitendinosus,** the smallest of the three flexor muscles, *arises* from the tuberosity of the ischium in common with the biceps femoris; also from the medial border of the tendon of the biceps femoris above. Its fibers terminate in a tendon which rests upon the semimembranosus and passes over the internal lateral (*tibial collateral*) ligament of the knee-joint, assists in forming the medial boundary of the popliteal space, winds around the medial tuberosity (*medial condyle*) of the tibia, and is *inserted* into the proximal part of the medial surface of the tibia, below the tendon of the gracilis, and behind that of the sartorius. From its insertion an expansion is given off which becomes continuous with the deep fascia of the leg. At about its middle a tendinous intersection is usually

observed. Like the biceps femoris, it is covered proximally by the gluteus maximus muscle. The tendons of the gracilis, the semitendinosus, and the sartorius are separated from the internal lateral (*tibial collateral*) ligament of the knee-joint by a bursa.

Nerve Supply.—From the great sciatic (*sciatic*) nerve.

Action.—The semitendinosus is a flexor as well as a medial rotator of the leg; taking its fixed point from below, it is also an extensor of the hip.

The **semimembranosus muscle,** so called from the membranous appearance of its superior and inferior surfaces, is situated along the posterior and the medial aspects of the thigh between the two preceding muscles and the adductor magnus, upon which it lies. It *arises* from the tuberosity of the ischium, lateral to the semitendinosus and biceps femoris, and is *inserted* by a thick tendon into the back part of the medial tuberosity (*medial condyle*) of the tibia. Between the tendon and the medial head of the gastrocnemius and the medial condyle is a large synovial bursa. (See description of the popliteal bursæ.) From the tendon are derived three expansions: one passes beneath the internal lateral (*tibial collateral*) ligament (a synovial bursa intervening) to the groove at the back of the medial tuberosity (*medial condyle*) of the tibia; one runs to the lateral condyle, forming the principal portion of the posterior ligament of the knee, or ligament of Winslow (*oblique popliteal ligament*), and the third one passes over the popliteus muscle to form its fascial covering.

Nerve Supply.—From the great sciatic (*sciatic*) nerve.

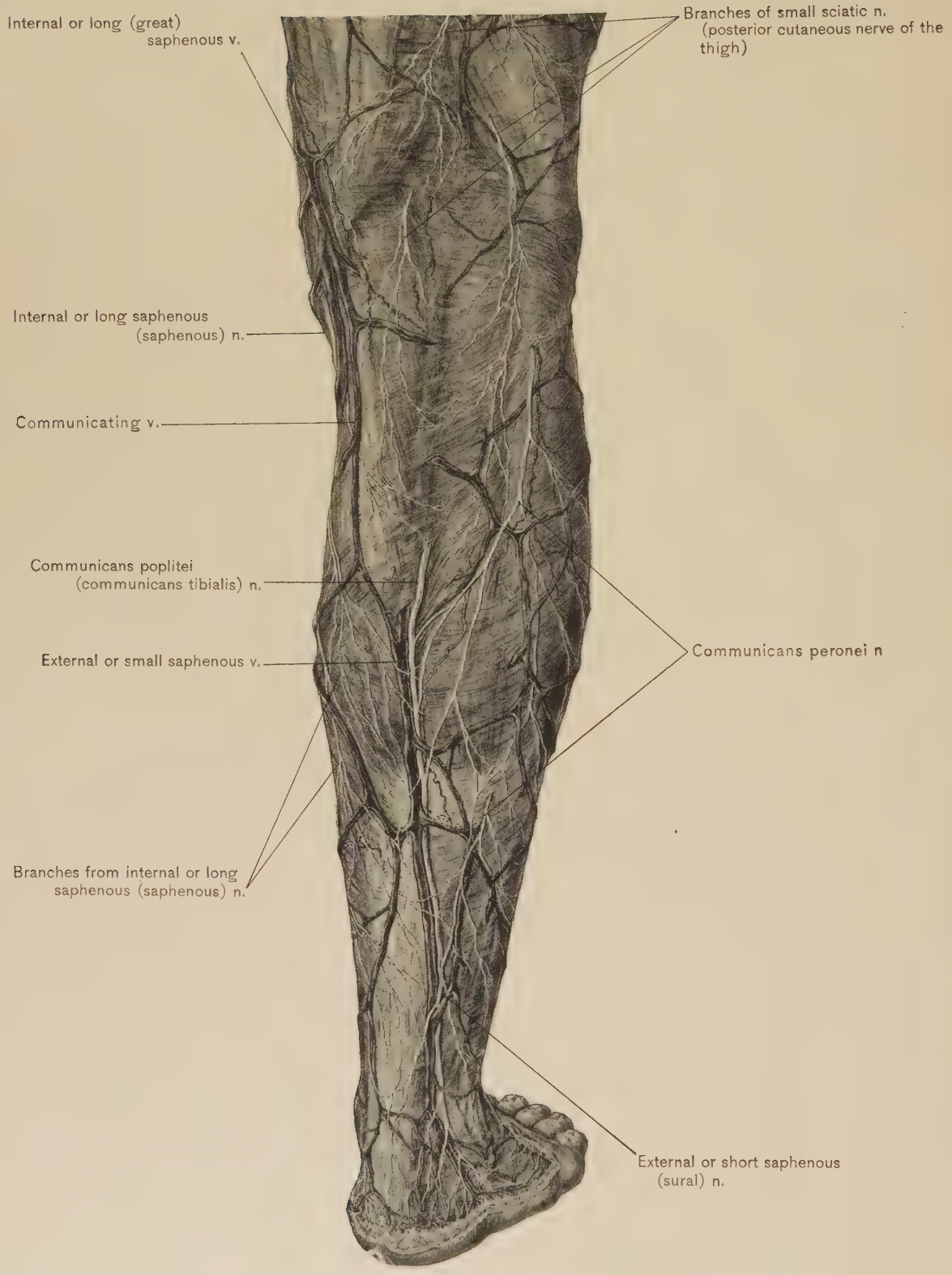
Action.—The semimembranosus, like the semitendinosus, is a flexor and a medial rotator of the leg; when taking its fixed point from below, it is an extensor of the hip, and also plays a very important part in retaining the body in the erect position.

The Action of the Muscles of the Thigh.—"To put the action of the muscles of the thigh on the pelvis in the clearest point of view, let us suppose we are standing upon one leg; the bones of the lower extremity represent a pillar which supports the weight of the trunk on a ball-and-socket joint; the weight is nicely balanced on all sides, and prevented from falling by four groups of muscles" (Holden). In front are the rectus femoris and sartorius; on the medial side, the adductors; on the lateral side, the gluteus medius and minimus, and behind, the hamstring and gluteus maximus muscles.

Nerve and Blood Supply of the Flexors.—The flexor group of muscles receives its nerve supply from the great sciatic (*sciatic*), and its blood supply from the perforating branches of the deep femoral and the muscular branches of the popliteal.

The **great sciatic** (**sciatic**) **nerve** leaves the gluteal region under cover of the gluteus maximus, descends upon the adductor magnus and beneath the long head

PLATE CCCX.


Internal or long (great) saphenous v.
Branches of small sciatic n. (posterior cutaneous nerve of the thigh)
Internal or long saphenous (saphenous) n.
Communicating v.
Communicans poplitei (communicans tibialis) n.
External or small saphenous v.
Communicans peronei n
Branches from internal or long saphenous (saphenous) n.
External or short saphenous (sural) n.

CUTANEOUS VESSELS AND NERVES OF THE BACK OF THE LEG.

of the biceps femoris, and runs along the lateral border of the semimembranosus. At about the middle of the thigh it divides into its two terminal divisions, the external popliteal (*common peroneal*) and internal popliteal (*tibial*) nerves.

THE BACK OF THE LEG

DISSECTION.—Extend the incision made in the dissection of the popliteal space along the middle of the calf to the sole of the foot; then carry a transverse incision around the heel, extending it along the sides of the foot. Reflect the skin and expose the superficial fascia.

In the superficial fascia of the leg are: the superficial vessels and nerves, the most important of which are the long (*great*) and short (*small*) saphenous veins, and the long saphenous (*saphenous*), the short saphenous (*sural*), and the communicans peronei nerves.

On the medial side of the leg are the **long (great) saphenous vein** and the **long saphenous (saphenous) nerve,** both of which have been described in the dissection of the front of the leg.

In the middle of the back of the leg is seen the **short (small) saphenous vein.** It begins on the lateral side of the dorsum of the foot in the dorsal venous arch and passes behind the external (*lateral*) malleolus to reach the leg. It leaves the superficial fascia at the distal part of the popliteal space by piercing the popliteal fascia, and empties into the popliteal vein. In the distal part of the leg it is accompanied by the short saphenous (*sural*) nerve, and in the proximal part by the small sciatic (*posterior cutaneous nerve of the thigh*). Both the long (*great*) and short (*small*) saphenous veins receive numerous veins in their course. They are guarded by several valves.

The cutaneous nerves (Plate CCCX) seen in the superficial fascia are branches of the internal cutaneous (*medial cutaneous nerve of thigh*), upon the medial side and proximally; of the long saphenous (*saphenous*), upon the medial side and distally; of the small sciatic (*posterior cutaneous nerve of the thigh*), in the middle and proximally; of the short saphenous (*sural*), distally; and, laterally, branches of the communicans peronei nerve.

The **short saphenous (sural) nerve,** which is formed by a branch of the internal popliteal (*tibial*), the communicans tibialis (*medial sural*), and a branch of the external popliteal (*common peroneal*), the communicans peronei, pierces the deep fascia at about the middle of the leg and accompanies the short (*small*) saphenous vein down the leg behind the lateral malleolus. At the distal part of the leg the nerve runs lateral to and a little in front of the tendo Achillis (*tendo calcaneus*). An incision for exposing the nerve should be made parallel with and

a little in advance of the lateral margin of the tendo Achillis, and behind the proximal part of the lateral malleolus.

In some cases the **communicans peronei nerve,** a branch of the external popliteal (*common peroneal*), instead of joining the short saphenous (*sural*) nerve where it pierces the deep fascia, descends to the heel as a separate nerve.

Cutaneous arteries accompany the superficial veins and nerves of the leg.

Dissection.—Reflect the superficial fascia, by making incisions similar to those made in reflecting the skin; this will bring deep fascia into view.

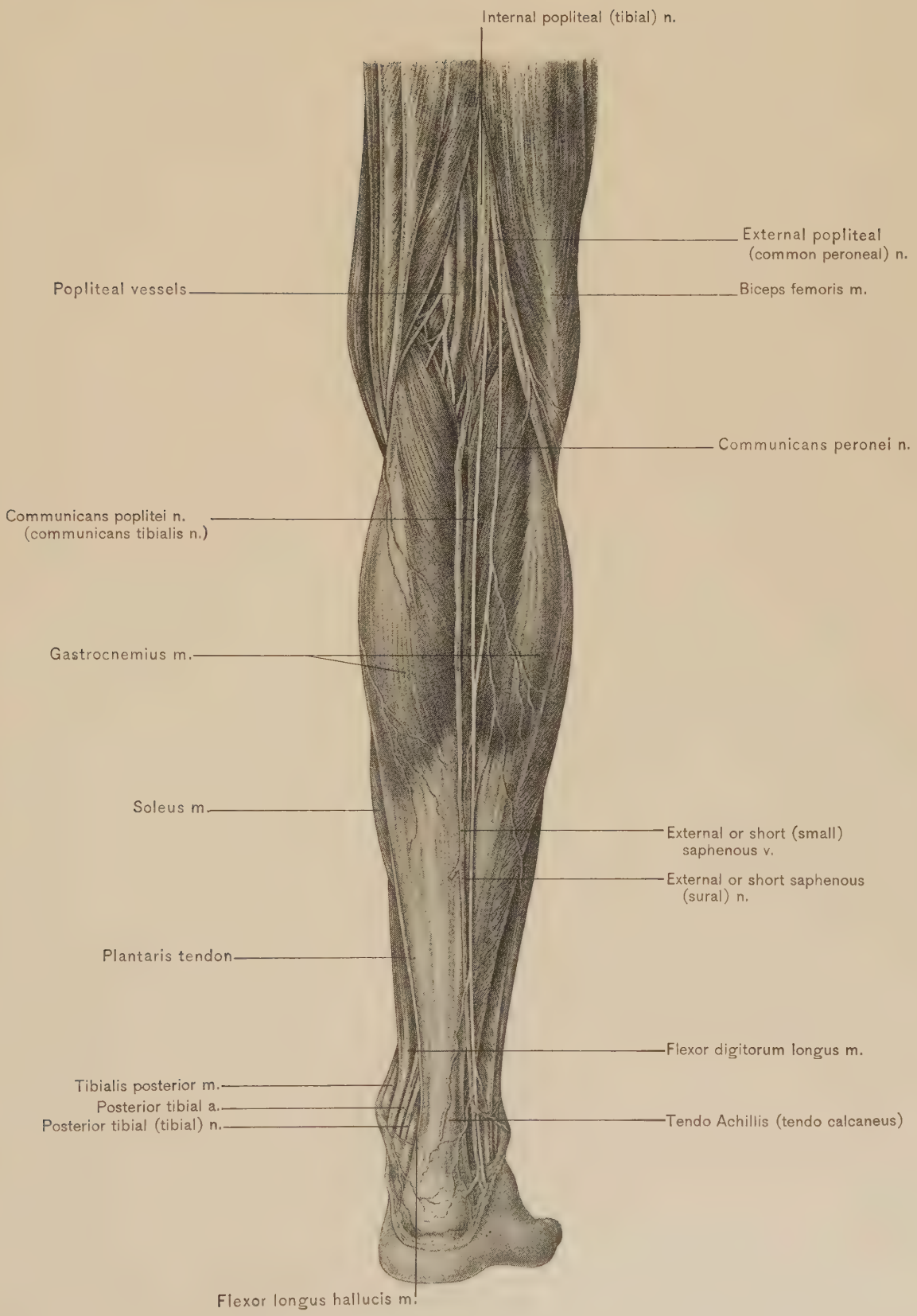
The deep fascia upon the back of the leg is continuous with the popliteal fascia above and with the external annular ligament (*peroneal retinacula*) and internal annular ligament (*ligamentum laciniatum*) of the ankle-joint below. Proximally, it receives offsets from the tendons of the biceps femoris, semimembranosus, semitendinosus, sartorius, and gracilis. These muscles, by their contraction, make tense the fascia of the leg. A transverse partition of the deep fascia, called the *deep transverse fascia*, extends across the leg between the superficial set of muscles (the gastrocnemius, plantaris, and soleus) and the deep set (the tibialis posterior, flexor digitorum longus, and flexor hallucis longus), and covers, also, the main vessels of the back of the leg. It is stronger below, where it joins the internal annular ligament (*ligamentum lacinatum*) at the ankle, than it is above. In the ligation of the posterior tibial artery the medial edge of this transverse partition of the fascia constitutes a very important landmark. The deep fascia of the leg is thinner behind than in front.

Dissection.—Reflect the deep fascia by incisions corresponding to those made through the skin and superficial fascia, care being taken not to destroy the short saphenous (*sural*) nerve. This exposes the superficial muscles of the back of the leg.

The muscles of the back of the leg are divided into two sets: a superficial and a deep. The superficial set comprises the gastrocnemius, the plantaris, and the soleus. The deep set includes the popliteus, the flexor digitorum longus, the tibialis posterior, and the flexor hallucis longus.

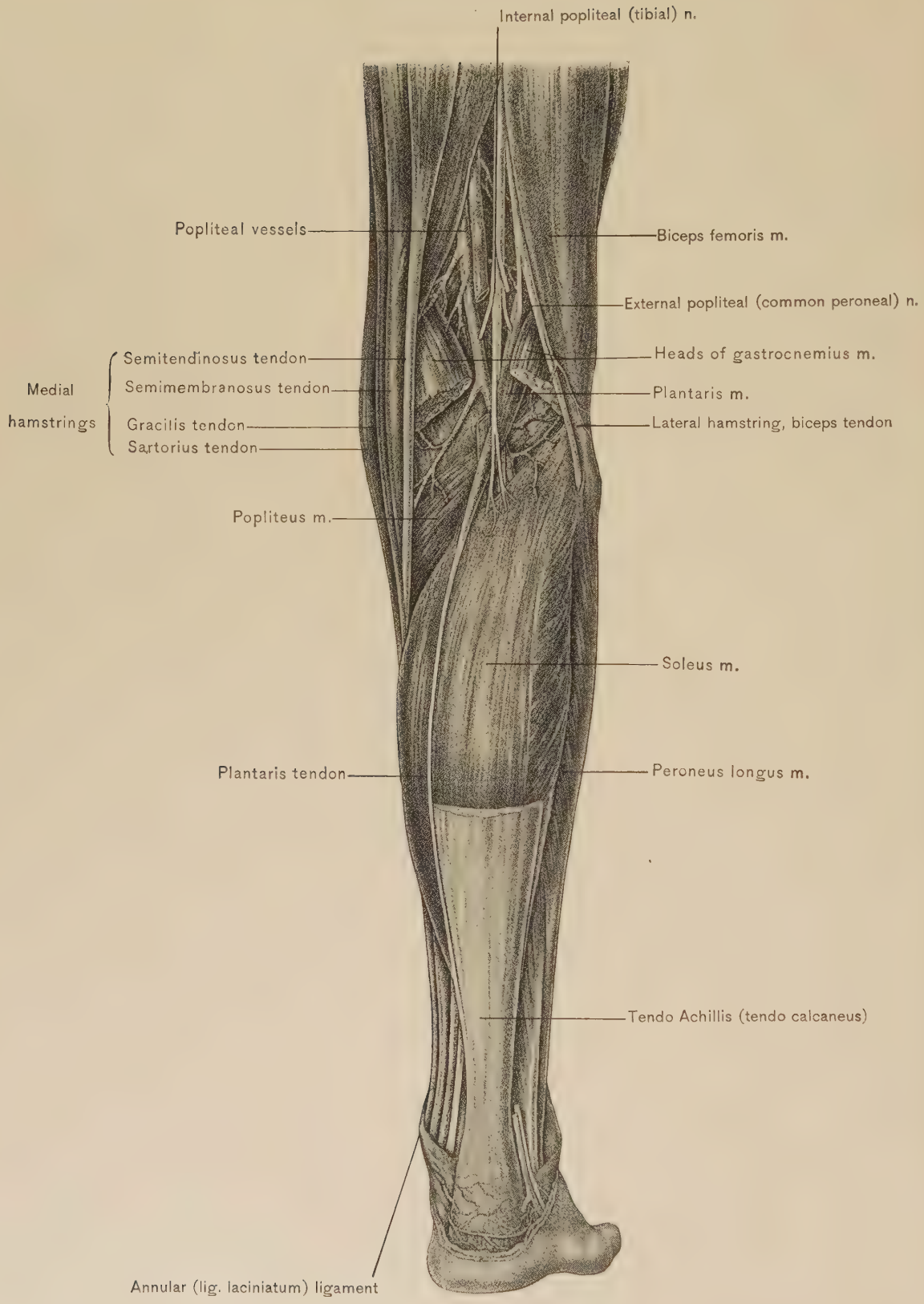
The **gastrocnemius muscle** (Plate CCCXI) *arises* by two heads from the back of the condyles of the femur. The medial head, the larger, *arises* from a depression at the proximal part of the medial condyle behind the insertion of the tendon of the adductor magnus and from a rough ridge on the popliteal surface of the femur. The lateral head *arises* from the proximal and back part of the lateral condyle above the origin of the popliteus and from a small area on the popliteal surface of the femur just adjacent to the condyle. The two heads descend and form the two bellies of the muscle, the medial being the larger. Below the middle of the leg they, with the soleus, terminate in the common ten-

PLATE CCCXI.



GASTROCNEMIUS MUSCLE.

PLATE CCCXII.



SOLEUS AND PLANTARIS MUSCLES.

don of *insertion*—the *tendo Achillis* (*tendo calcaneus*). The heads of the gastrocnemius assist in forming the distal, medial, and lateral boundaries of the popliteal space. Between the medial head and the medial condyle of the femur there is a bursa which may be continuous with the synovial cavity of the knee-joint. In the lateral head is commonly found a piece of fibrous cartilage, or in some cases a sesamoid bone. Under this head a bursa, presenting relations similar to the one under the medial head, may be found. The deep surface of the muscle is in relation with the popliteus, the plantaris, and the soleus muscles, the popliteal vessels, and the internal popliteal (*tibial*) nerve. Two large branches of the popliteal artery (the sural) enter the heads of the muscle to supply it.

Nerve Supply.—The nerve supply is derived from the internal popliteal (*tibial*) nerve.

Action.—The gastrocnemius is an extensor of the ankle. When taking its fixed point at the os calcis (*calcaneus*), it is a flexor of the knee-joint.

Dissection.—Cut across the two heads, at the junction with the belly of the muscle, and reflect the two portions of the muscle. This will expose the under surface of the gastrocnemius and the upper surface of the soleus, both of which are covered with a glistening aponeurosis, the plantaris tendon, and the vessels and nerves entering the heads of the muscle.

The **plantaris,** a very small muscle, has the longest tendon of any muscle in the body, and corresponds to the palmaris longus of the forearm. It *arises* from the epicondylic line leading from the linea aspera to the lateral condyle of the femur and from the posterior (*oblique popliteal*) ligament of the knee-joint. Its belly is about five centimeters (two inches) in length and terminates in a tendon which passes obliquely between the gastrocnemius and soleus muscle and runs along the medial border of the tendo Achillis (*tendo calcaneus*) to be *inserted* into the medial side of the tuberosity of the os calcis (*calcaneus*). Occasionally, its tendon is inserted into the tendo Achillis (*tendo calcaneus*), or the internal annular ligament (*ligamentum laciniatum*).

Nerve Supply.—Its nerve supply is from the internal popliteal (*tibial*) nerve.

Action.—It assists the gastrocnemius, being an extensor of the ankle when the foot is not fixed, and a flexor of the knee when acting from its point of insertion. This muscle is sometimes absent.

The **soleus** (Plate CCCXII) is a large flat muscle arising by two heads. The lateral head *arises* from the posterior surface of the head of the fibula and from the proximal third of the posterior and medial surface of the shaft of the same bone. The medial head *arises* from the oblique line of the tibia, from the middle third of the medial border of the tibia, and from a tendinous arch between the

tibia and fibula (*arcus tendineus solei*). Beneath this arch pass the posterior tibial vessels and nerve. Its fibers terminate in a broad tendon, which, with the tendon of the gastrocnemius, forms the *tendo Achillis* (*tendo calcaneus*). The under surface of the muscle, like the upper, is covered by an aponeurosis.

Nerve Supply.—The nerve supply is derived from the internal popliteal (*tibial*).

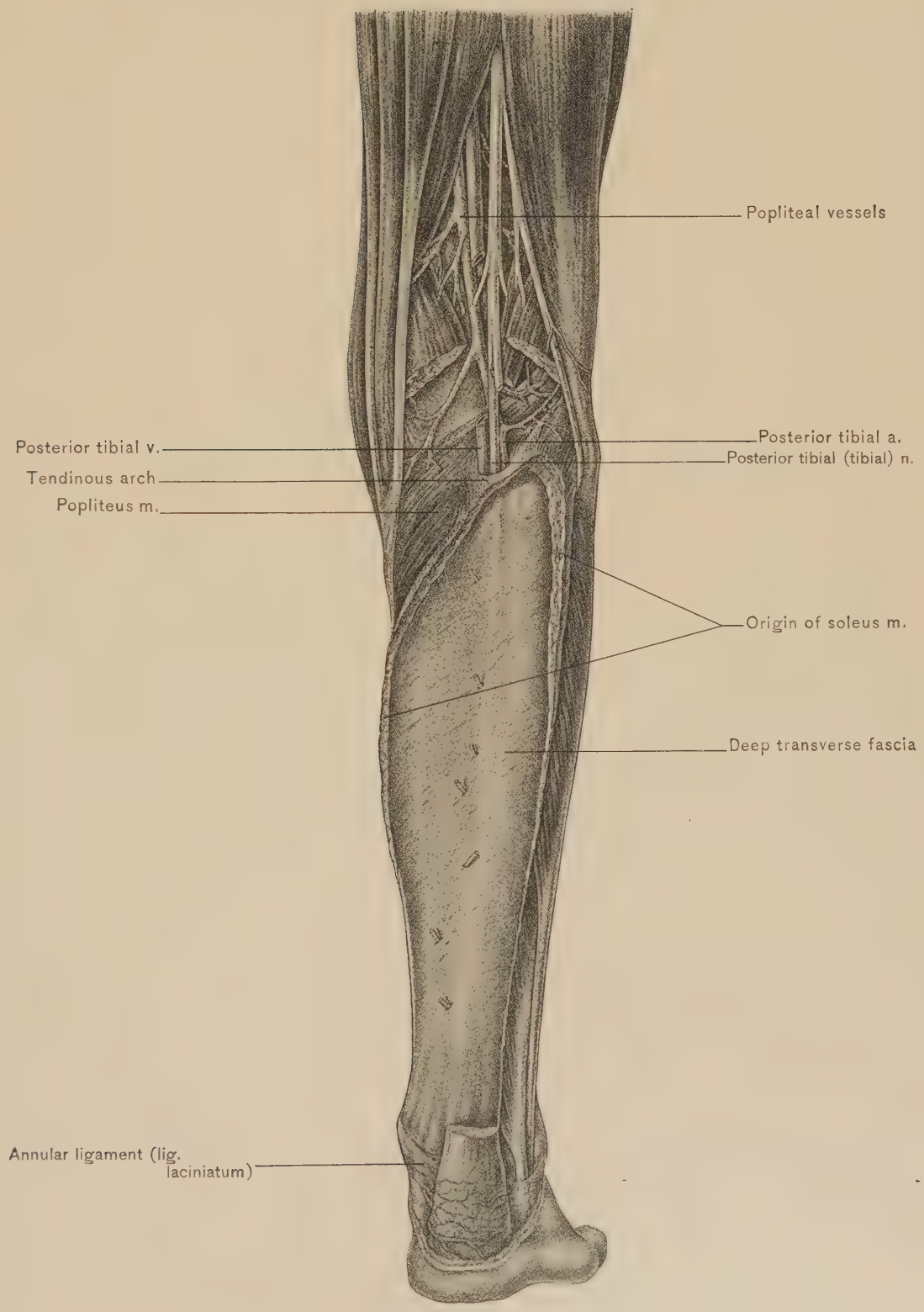
Action.—It is an extensor of the ankle.

The **tendo Achillis** (**tendo calcaneus**) is formed by the union of the tendons of the gastrocnemius and soleus muscles. It begins about the middle of the leg, and at first is of considerable size, but gradually becomes narrower and thicker as it descends. This tendon is divided in operations for certain forms of club-foot, such as talipes equinus. The most convenient as well as the safest place for division is about four centimeters (one inch and a half) above its insertion into the tuberosity of the os calcis (*calcaneus*). Between the tendon and the bone is a large quantity of fat, and between the mass of fat and bone is a synovial bursa. Numerous cases have been reported of rupture of the gastrocnemius muscle and the tendo Achillis (*tendo calcaneus*) during violent exertion. In contact with the lateral side of the tendon, but superficial to it, are the short (*small*) saphenous vein and short saphenous (*sural*) nerve.

Dissection.—Detach the medial and lateral heads of the soleus muscle and expose the tibia and fibula, and the transverse intermuscular partition of the deep fascia of the leg. Next remove the fascia covering the popliteus muscle, and the deep transverse fascia of the leg, bringing into view the posterior tibial vessels and nerve, the peroneal vessels, and the deep muscles (Plate CCCXIII).

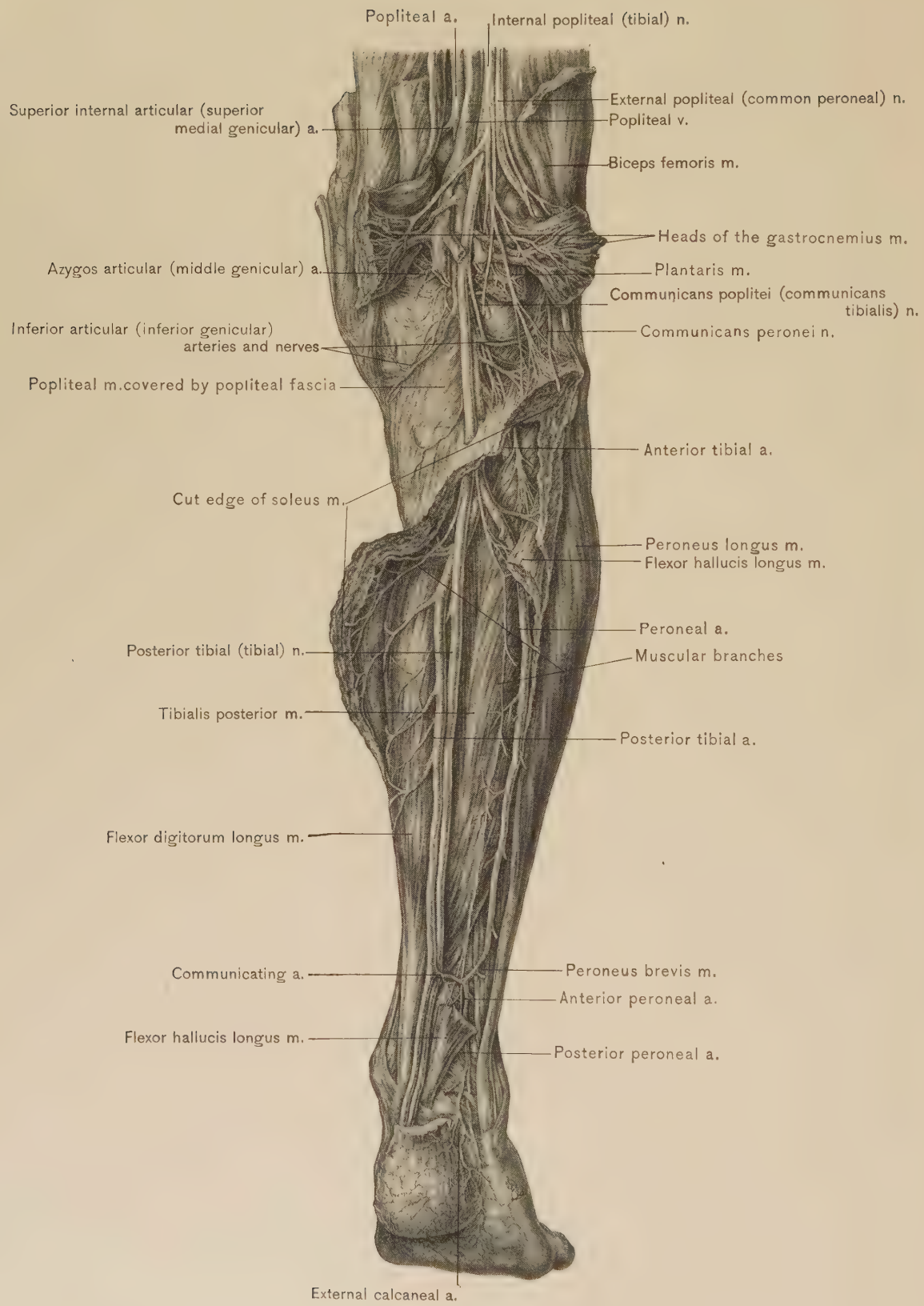
The **posterior tibial artery,** the larger of the two terminal divisions of the popliteal, commences at the distal border of the popliteus muscle and extends down the leg between the superficial and deep set of flexors. It rests upon the posterior surface of the tibialis posterior muscle in the proximal two-thirds of its course, and upon the flexor digitorum longus muscle and the tibia in the distal part. Reaching the interval between the medial malleolus and the os calcis (*calcaneus*), it passes beneath the internal annular ligament (*ligamentum laciniatum*) and ends in the sole of the foot, dividing beneath the origin of the abductor hallucis into the internal (*medial*) and external (*lateral*) plantar arteries. In the proximal part of the leg the artery is deep-seated, making its ligation difficult; in the distal part of the leg it is more superficial, being covered only by the integument and superficial and deep fasciæ. Above the medial malleolus it runs parallel with the tendo Achillis (*tendo calcaneus*), while behind the medial malleolus it is between the tendon of the flexor digitorum longus and the flexor hallucis longus. It is accompanied by two veins, the venæ comites, and by the posterior

PLATE CCCXIII.



DEEP TRANSVERSE FASCIA.

PLATE CCCXIV.



PERONEAL ARTERY.

tibial (*tibial*) nerve, which is about the size of the musculo-spiral (*radial*). At its commencement and in the proximal part of the leg the nerve lies to the medial side of the artery. It then crosses beneath the vessel to reach its lateral side, and for the remainder of its course lies lateral and posterior to the artery. Behind the medial malleolus the nerve lies between the artery and the tendon of the flexor hallucis longus muscle. A line drawn from the middle of the popliteal space to the point midway between the medial malleolus and the os calcis (*calcaneus*) will represent the course of the artery.

Accompanying the posterior tibial artery are the two posterior tibial veins (*venæ comites*). They are formed by the union of the internal (*medial*) and external (*lateral*) plantar veins. They receive the peroneal veins; at the lower border of the popliteus muscle they are joined by the anterior tibial veins to form the *popliteal vein.*

Ligation of the Posterior Tibial Artery.—When ligating the proximal third of the artery the incision is made along the medial edge of the tibia and the skin, and the superficial and deep fasciæ are divided, care being taken to avoid the long (*great*) saphenous vein and nerve. This opens up the interval between the gastrocnemius and soleus muscles, occupied by the plantaris tendon; this should not be mistaken for the interval between the transverse intermuscular septum and the posterior tibial muscle, occupied by the posterior tibial vessels and posterior tibial (*tibial*) nerve, as these structures are not exposed until the medial head of the soleus is separated from the tibia, and the transverse intermuscular septum is incised. The medial head of the soleus is then cut from the tibia and reflected, exposing the transverse partition of the deep fascia extending from the medial to the lateral aspect of the leg between the superficial and deep set of muscles. This must be divided, to expose the posterior tibial vessels and posterior tibial (*tibial*) nerve.

The posterior tibial artery rarely requires ligation in its proximal third, except in cases of punctured wound from the front of the leg, and of traumatic aneurysm of the vessel low down. In cases of injury, with bleeding from the posterior tibial, both ends of the vessel should be exposed and tied.

The branches of the posterior tibial artery are: the peroneal, the muscular, the fibular, the cutaneous, the nutrient, the communicating, the internal (*medial*) malleolar, medial calcanean, and the terminal branches, the external (*lateral*) and internal (*medial*) plantar arteries.

The **peroneal artery** (Plate CCCXIV) is the largest branch of the posterior tibial, and is often as large as the main trunk. It arises about two and a half centimeters (one inch) below the bifurcation of the popliteal artery, and passes down the leg close to the fibula. Above, it rests upon the tibialis posterior

muscle, and below upon the interosseous membrane and the tibio-fibular articulation, being overlapped, where it comes in contact with the fibula, by the medial border of the flexor hallucis longus. It passes to the lateral side of the heel, where it anastomoses with the medial calcanean branch of the external (*lateral*) plantar artery, and with the metatarsal and tarsal branches of the dorsalis pedis artery. The artery may be injured in fractures of the fibula and because of its size a large hematoma may result.

The branches of the peroneal artery are: the anterior peroneal (*the perforating*), the nutrient, the muscular, the communicating, the cutaneous, and the terminal, or posterior peroneal.

The *anterior peroneal artery* (*perforating branch*) is given off from the peroneal artery a short distance above the ankle. It passes through the interosseous membrane to reach the dorsal and lateral part of the foot, where it anastomoses with the tarsal and external (*lateral*) malleolar arteries. It is covered by the peroneus tertius muscle and passes beneath the horizontal portion of the anterior annular (*transversum cruris*) ligament. In cases where the anterior tibial artery is small and terminates at the ankle, the anterior peroneal artery (*perforating branch*) is large and takes the place of the dorsalis pedis.

The *nutrient artery of the fibula* is a branch of the peroneal.

The *muscular branches* of the peroneal artery supply the deep muscles and the soleus.

The *communicating branches* anastomose in front of the tendo Achillis (*tendo calcaneus*) with the communicating branch of the posterior tibial.

The *cutaneous branches* supply the skin over the lateral side of the leg.

The *terminal branch*, or *posterior peroneal*, is the continuation of the peroneal artery. It gives origin to the lateral calcanean branch which anastomoses with the medial calcanean branch of the posterior tibial and the tarsal and metatarsal branches of the dorsalis pedis arteries.

Ligation of the Peroneal Artery.—In the ligation of the peroneal artery the lateral head of the soleus muscle should be detached, and the lateral border of the deep transverse fascia divided. This opens the space between the partition of the fascia and the tibialis posterior muscle and exposes the peroneal vessels.

The *muscular branches* of the posterior tibial artery supply the flexor digitorum longus, flexor hallucis longus, and soleus muscles.

The *fibular branch* passes to the neck of the fibula to anastomose with the sural and external inferior articular (*lateral inferior genicular*) branches of the popliteal.

The *cutaneous branches* are distributed to the skin of the posterior and medial aspects of the leg.

The *nutrient artery of the tibia* is a branch of the posterior tibial, given off near its commencement.

The *communicating artery* arises from the posterior tibial at the distal part of the leg and passes transversely beneath the tendon of the flexor hallucis longus to anastomose with a branch of the peroneal, thus forming an arch.

The *internal (medial) calcanean arteries* are several branches which arise from the posterior tibial near the medial malleolus and which ramify over the posterior and medial aspects of the heel, anastomosing with the internal (*medial*) malleolar and peroneal arteries.

The *internal (medial) malleolar branches* run beneath the flexor digitorum longus and the tibialis posterior tendons to anastomose over the medial malleolus with the internal (*medial*) malleolar branch of the anterior tibial artery.

The *plantar arteries* will be described with the foot.

The **posterior tibial (tibial) nerve** is the continuation of the internal popliteal (*tibial*), and passes down the leg in company with the posterior tibial artery. In the proximal part of the leg it lies to the medial side of the artery; it then crosses beneath the artery to its lateral side, and for the remainder of its course it lies lateral to and behind the artery. In the distal part of the leg it runs parallel with the medial margin of the tendo Achillis (*tendo calcaneus*) as far as the interval between the medial malleolus and os calcis (*calcaneus*), where it divides into its two terminal branches—the internal (*medial*) and the external (*lateral*) plantar nerves.

The branches of the posterior tibial nerve (*tibial*) are the muscular, the medial calcanean, the articular and the two terminal branches, the external (*lateral*) and internal (*medial*) plantar nerves.

The *muscular branches* supply the tibialis posterior, the soleus, the flexor hallucis longus and the flexor digitorum longus.

The *medial calcanean branch* arises from the nerve above the heel, pierces the internal annular ligament (*ligamentum laciniatum*), and passes through the superficial fascia to supply the integument covering the medial and under surface of the heel and foot.

The *articular branches* are small twigs which supply the ankle-joint.

The *plantar nerves* will be described with the foot.

The deep muscles of the leg are the popliteus, the flexor digitorum longus, the flexor hallucis longus, and the tibialis posterior.

The **popliteus muscle** forms the distal part of the floor of the popliteal space, and extends obliquely from the lateral border of the knee-joint to the medial part of the leg above. It *arises* by a strong tendon from a groove on the lateral side of the lateral condyle of the femur, and by a slip from the posterior (*oblique popliteal*) ligament of the knee-joint, its origin being covered by the tendon of the biceps

femoris and the external lateral (*fibular collateral*) ligament of the knee-joint. The tendon is within the capsule of the knee-joint and grooves the lateral semilunar fibro-cartilage, in this location receiving an investment from the synovial membrane of the knee. Hence it holds the same relation to the knee-joint as the long tendon of the biceps brachii does to the shoulder-joint. Its fibers pass downward and medially and are *inserted* into the triangular surface of the tibia above the oblique line and into the fascia covering the surface of the muscle. It rests on the back of the tibia and on the superior tibio-fibular articulation. The fascia covering its surface is in relation with the popliteal vessels, the internal popliteal (*tibial*) nerve, and the gastrocnemius and plantaris muscles.

Nerve Supply.—From the internal popliteal (*tibial*) nerve.

Action.—The action of the muscle is to flex the leg and rotate it medialward.

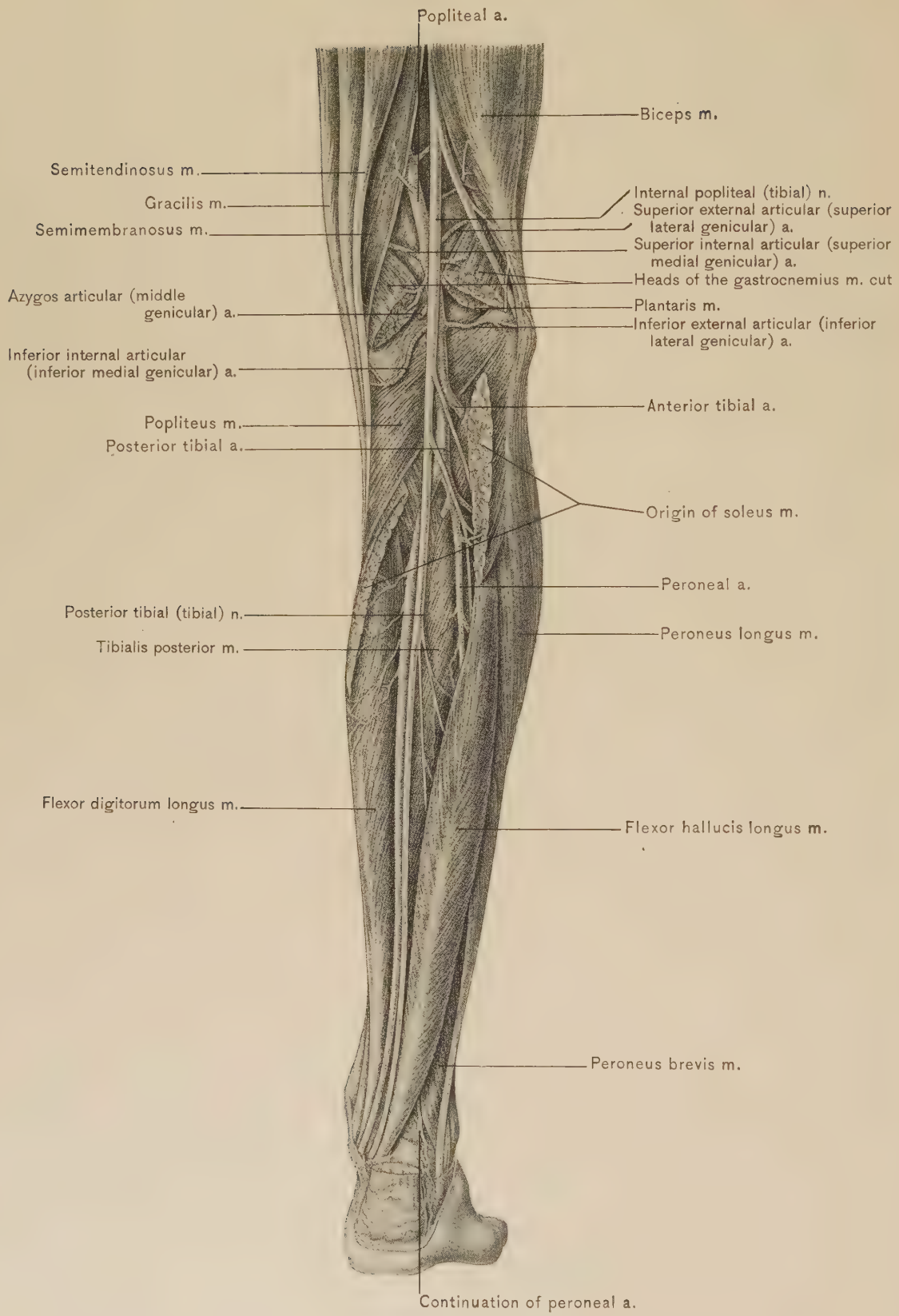
The **flexor digitorum longus muscle** is situated on the medial side of the leg and *arises* from the posterior surface of the tibia below the oblique line to about seven and a half centimeters (three inches) from the medial malleolus, and from the partition of the fascia between it and the tibialis posterior. The fibers terminate in a tendon on the medial border of the muscle which passes through a groove common to it and the tibialis posterior behind the medial malleolus. It enters the sole of the foot and divides into *four tendons* which are *inserted* into the terminal phalanges of the second, third, fourth, and fifth toes. The lumbricales take their origin from its tendons. The posterior tibial vessels and posterior (*tibial*) nerve rest upon the upper surface of the muscle, as does the soleus muscle.

Nerve Supply.—From the posterior tibial (*tibial*) nerve.

Action.—It flexes the phalanges, extends the foot and causes slight inversion of the sole.

The **flexor hallucis longus muscle,** situated on the lateral side of the leg, is the largest and most superficial of the deep set of flexors. It *arises* from the distal two-thirds of the posterior surface of the fibula below the soleus, from the partition of the fascia between it and the peroneal muscles, from the distal part of the interosseous membrane, and from the aponeurosis over the tibialis posterior. Its fibers terminate in a tendon situated on the posterior surface of the muscle. The tendon passes through grooves, one on the back of the distal end of the tibia, one on the back of the astragalus (*talus*), and one beneath the lower process (*sustentaculum tali*) of the os calcis (*calcaneus*), to reach the sole of the foot, where it is *inserted* into the distal phalanx of the great toe. The depression along the lateral border of the muscle contains the peroneal vessels; along its medial border are the posterior tibial vessels and posterior tibial (*tibial*) nerve.

PLATE CCCXV.



DEEP MUSCLES OF THE BACK OF THE LEG, POSTERIOR TIBIAL ARTERY AND POSTERIOR TIBIAL (TIBIAL) NERVE.

Nerve Supply.—From the posterior tibial (*tibial*) nerve.

Action.—Its action is to flex the distal phalanx of the great toe and to extend the foot.

The **tibialis posterior muscle** (Plate CCCXV) is situated between the flexor digitorum longus and the flexor hallucis longus, and is the deepest of all the flexor muscles, being partially concealed by the borders of these two muscles. It *arises* from the posterior surface of the interosseous membrane by two processes between which the anterior tibial vessels pass, from about the intermediate three-fourths of the posterior surface of the tibia and posterior part of the medial surface of the fibula, and from the deep fascia covering it. It terminates in a tendon in the distal fourth of the leg, which passes anterior to the tendon of the flexor digitorum longus, and accompanies it through the same groove behind the medial malleolus, but in a separate synovial membrane. It enters the sole of the foot to be *inserted* into the tuberosity of the scaphoid (*navicular*) and the inner (*first*) cuneiform bones. The tendon gives off fibrous slips to be *inserted* into the middle (*second*) and outer (*third*) cuneiform bones, the second, third and fourth metatarsals, the cuboid and the os calcis (*calcaneous*). The proximal part of the muscle is beneath the intermuscular partition of fascia, and is overlapped by the flexor digitorum longus. The tendon lies close to and parallel with the medial edge of the tibia below. Its synovial sheath extends a little distance above the medial malleolus, and is opened in the operation of division of the tendon for the correction of talipes varus. In performing a tenotomy on the tibialis posterior, the foot should be extended to relax the tendon, and the tenotome introduced above the medial malleolus. The tenotome should hug the medial edge of the tibia until the interval between the tibia and the tendon is reached, then turn the blade of the instrument at right angles to the bone and divide the tendon.

Nerve Supply.—From the posterior tibial (*tibial*) nerve.

Action.—The action of the muscle is to extend the foot and turn it medialward.

THE SOLE OF THE FOOT

Dissection.—Place the leg in the same position as in the dissection of the back of the leg, with a block under the ankle; the tissues of the sole of the foot are put on the stretch by fixing the heel with hooks and by separating and fastening the toes. The incisions around the side to the heel made when dissecting the back of the leg, should be extended forward on the medial side to the ball of the great toe, and on the lateral side to the ball of the little toe, at which points they should be connected by a transverse incision across the sole of the foot at the

clefts of the toes; from this, vertical incisions should be made through the middle of the toes to their extremities. The skin, which is very thick and strong, should be reflected from behind forward as one flap, thus exposing the superficial fascia.

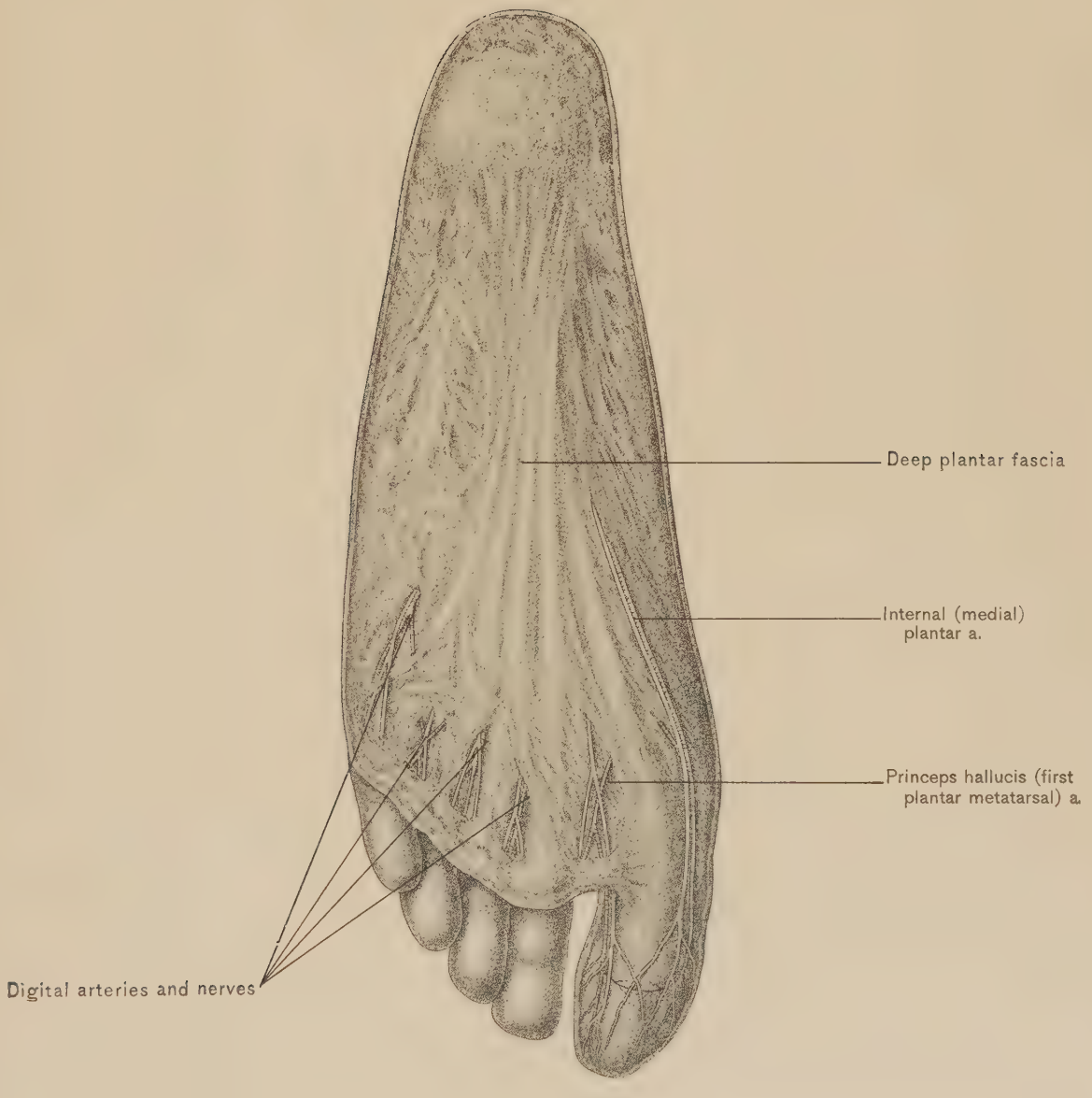
The **superficial fascia** is seen as a dense layer of fibrous tissue, greatly thickened by granular masses of fat separated by strong fibrous septa. By this arrangement elastic pads are formed over the heel and the balls of the great and little toes. In each of these pads is a bursa; there is also one beneath the os calcis (*calcaneus*) and one beneath the head of the metatarsal bone of the great toe and of the little toe. The fascia over the bony eminences is often twenty millimeters (three-fourths of an inch) thick, the greater part of it being distributed along the lateral and the medial margins of the foot. In the middle of the sole it is not so abundant, and the connection between the skin and the plantar fascia is more direct. The superficial fascia of the sole of the foot, like that of the palm of the hand and the scalp, consists of but one layer.

The difference between the density of the superficial fascia of the sole of the foot and the laxity of the same tissue upon the dorsum of the foot is very great. This accounts for the great swelling on the dorsum in cases of diffuse inflammation and in conditions producing edema. In the early stage of general dropsy the first part of the body to show the swelling is often the back of the foot. In the sole of the foot, inflammatory affections and effusions produce little external change, owing to the unyielding character of the parts involved. Collections of pus in the sole of the foot or heel tend to remain circumscribed; upon the dorsum they form readily and extend rapidly; in the sole they cause intense pain, owing to the density of the tissues. The fascia contains some cutaneous branches of the plantar nerves, the internal (*medial*) calcanean branch of the posterior tibial (*tibial*) nerve, perforating branches of the plantar vessels, and a great number of lymphatics and veins.

Dissection.—Remove the superficial fascia in the same manner as the skin, when the plantar fascia (deep fascia) will be brought into view.

The **plantar aponeurosis, or fascia** (Plate CCCXVI), holding, as it does, so important a relation to some kinds of the deformity known as club-foot, as well as to operations for the relief of the deformity, should be carefully studied. It is a very dense and strong tissue of a pearly white color. It extends from the under surface of the back part of the os calcis (*calcaneus*) to the heads of the metatarsal bones. It consists of three portions: a central, or main, portion, which is extremely dense and strong, and of special surgical importance; a medial portion, the one which is quite thin and of little surgical significance; a lateral portion, which is continuous with the fascia of the dorsum of the foot. It forms a very thick band between the os calcis (*calcaneus*) and the metatarsal bone of the little

PLATE CCCXVI.


Deep plantar fascia
Internal (medial) plantar a.
Princeps hallucis (first plantar metatarsal) a.
Digital arteries and nerves

DEEP PLANTAR APONEUROSIS OR FASCIA.

toe and covers the abductor digiti quinti. The medial portion covers the abductor hallucis muscle; medially, it is continuous with the fascia of the dorsum of the foot. The central portion is triangular in shape, with its apex at the os calcis (*calcaneus*), and its base anterior. The base of the central portion near the head of the metatarsal bones divides into five processes, between which the digital vessels and nerves and the tendons of the lumbricales muscles pass. Each of the five processes divides, opposite the metatarso-phalangeal joints, into two slips which embrace the sides of the flexor tendons and are inserted into the sides of the metatarsal bones, into the transverse metatarsal ligaments, and into the sheaths of the extensor tendons. In this way arches are formed for the passage of the flexor tendons in reaching the toes. At the point of division of the fascia into processes, and at the point of division of the processes, numerous transverse fibers bind them together and connect them with the skin, thus serving to increase the strength of the fascia at these points. At the junctions of the central portion with the lateral and medial portions of the fascia, two strong vertical septa, broader in front than behind, pass into the foot and separate the deep plantar group from the medial and lateral group of muscles; from these, again, medial transverse septa are derived which separate the various layers of muscles in this region. In the folds of the skin between the toes are ligamentous fibers, *the transverse ligaments of the toes*, which run from one side of the foot to the other, answering the same purpose as the ligaments of the hand. The central portion of the fascia assists in supporting the anteroposterior arch of the foot, which it tends to maintain in the same manner as the bowstring maintains the arch of the bow. The sinking of the arch that occurs in *talipes planus* (flat-foot) is attended with a marked yielding of this portion of the fascia. The plantar fascia is often found much contracted in certain forms of club-foot, such as talipes equinus and congenital talipes varus. The term *talipes arcuatus* is applied to a deformity which dep nds mainly or entirely upon the contraction of the plantar fascia. The best place to divide this fascia is about two and a half centimeters (one inch) in front of its attachment to the os calcis (*calcaneus*), this being its narrowest part. A collection of pus beneath the fascia will be very closely bound down and will usually extend in any direction other than through the fascia itself. Rarely suppuration will extend through the openings in the plantar fascia and become subcutaneous. This is the abscess *en bouton de chemise*, of the French. Such collections cause intense pain and often much destruction of tissue before they are discharged. They may open upon the dorsum of the foot, between the toes, may extend along the tendons of the ankle, or may point laterally through the intermuscular septa. The vertical portions of the deep fascia are too feeble to obstruct the progress of a deep-seated abscess.

Dissection.—Remove the plantar fascia by dividing it transversely about two and a half centimeters (one inch) in front of the os calcis and reflecting it, carefully separating it from the flexor digitorum brevis muscle, to which it gives origin, avoiding, in front, the digital vessels and nerves between its processes. The parts exposed in this dissection are: the flexor digitorum brevis muscle, occupying the center of the sole of the foot, and its four tendons, the tendons of the flexor digitorum longus, associated with which are the lumbricales muscles, and the terminal part of the digital arteries. Upon the medial side of the foot is seen the abductor hallucis, and upon the lateral side the abductor digiti quinti. Occupying the grooves between the flexor digitorum brevis and the abductor hallucis on the medial side, and the flexor digitorum brevis and the abductor digiti quinti upon the lateral side, are the internal (*medial*) and external (*lateral*) plantar arteries and nerves, respectively.

The muscles in the sole of the foot consist of four layers. The *first*, or *superficial, layer* comprises the flexor digitorum brevis, the abductor hallucis, and the abductor digiti quinti; the *second layer* comprises the flexor accessorius (*quadratus plantæ*) the lumbricales, the tendons of the flexor digitorum longus and of the flexor hallucis longus; the *third layer*, the flexor hallucis brevis, the adductor hallucis, the flexor digiti quinti brevis; the *fourth layer*, the interossei, four in number, the tendons of the tibialis posterior and the peroneus longus.

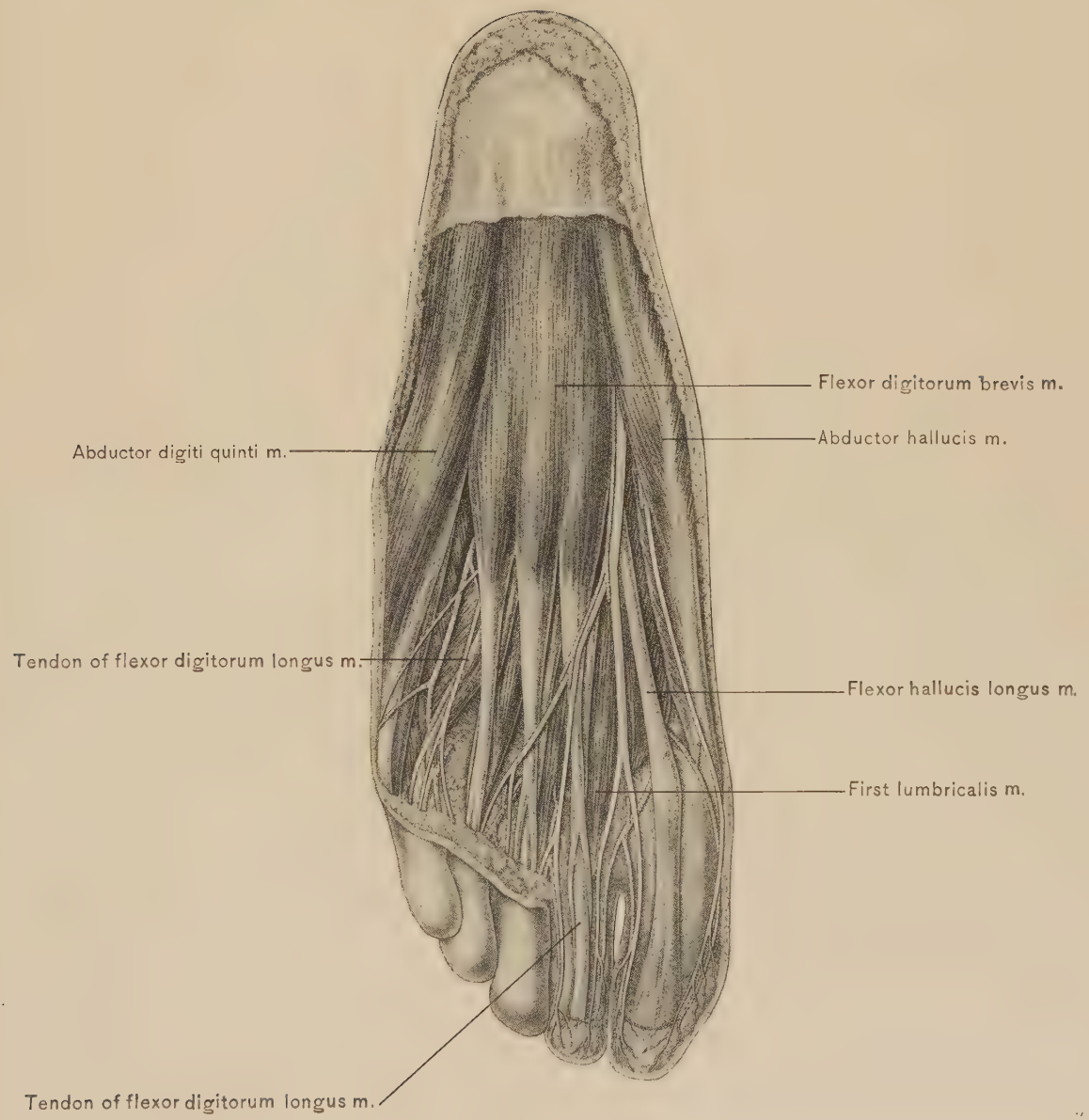
The **flexor digitorium brevis muscle** (Plate CCCXVII) lies immediately beneath the central part of the plantar fascia and *arises* from the under surface of the os calcis (*calcaneus*) between the abductor hallucis and the abductor digiti quinti, from the central portion of the plantar fascia and from the intermuscular septa between it and the muscles on either side. It passes forward and divides into four tendons which lie superficial to those of the flexor digitorum longus and end in the four lesser toes. Open the sheaths binding the tendons to the phalanges, and note that the tendons of the flexor brevis divide into two slips opposite the middle of the proximal phalanges, to allow the tendons of the flexor digitorum longus to pass through. The two slips are *inserted* into the sides of the second phalanges. In their insertion these tendons resemble the tendons of the flexor digitorum sublimis in the hand.

Nerve Supply.—From the internal (*medial*) plantar nerve.

Action.—The action is to flex the second phalanges of the toes. By continuing its action it causes flexion of the metatarso-phalangeal and medio-tarsal joints.

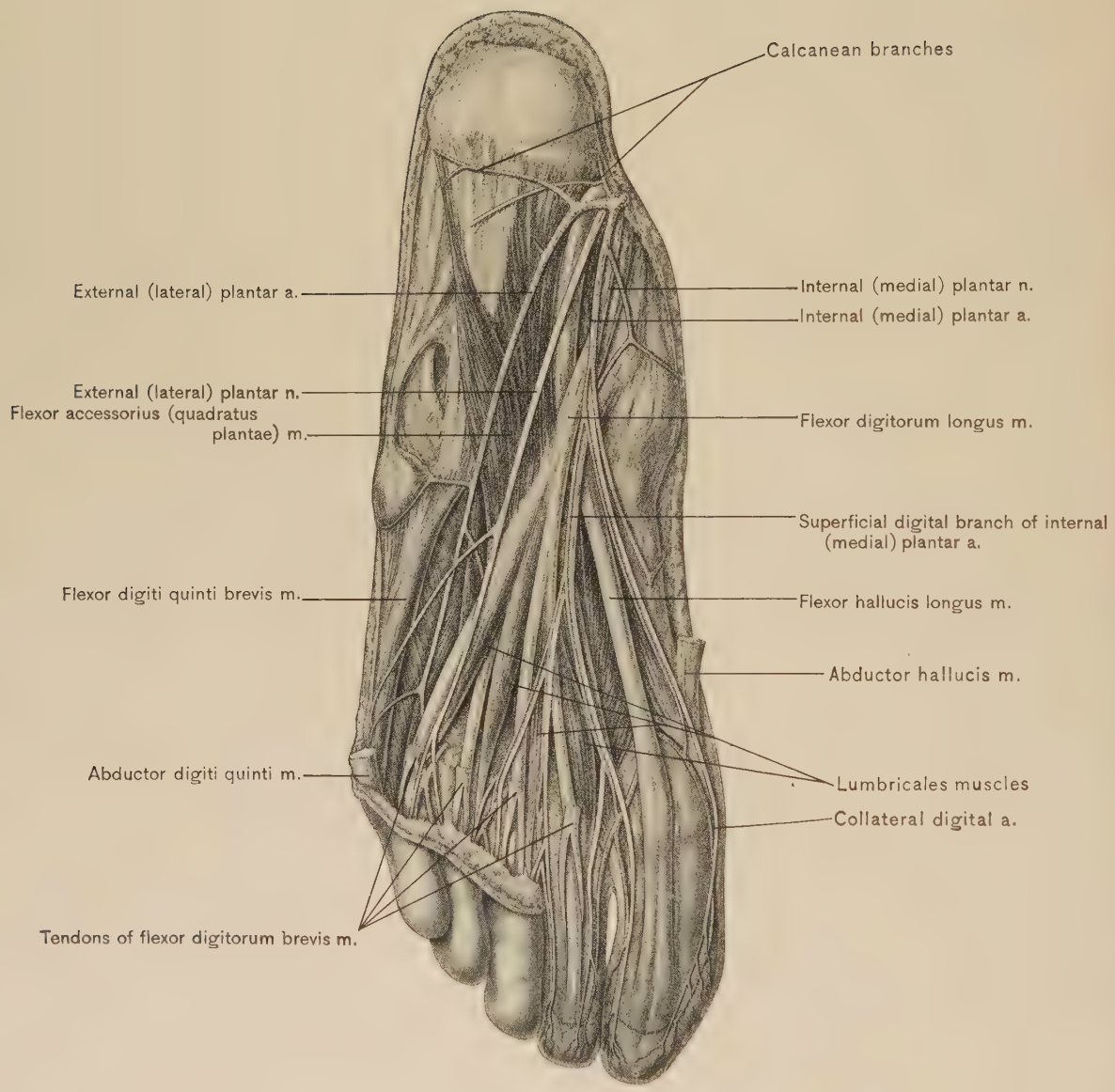
The **abductor hallucis muscle** lies along the medial side of the foot. It arises by two heads. The *lateral head arises* from the medial tuberosity on the under surface of the os calcis (*calcaneus*), from the medial portion of the plantar fascia,

PLATE CCCXVII.


Flexor digitorum brevis m.
Abductor digiti quinti m.
Abductor hallucis m.
Tendon of flexor digitorum longus m.
Flexor hallucis longus m.
First lumbricalis m.
Tendon of flexor digitorum longus m.

FIRST LAYER OF MUSCLES OF THE SOLE OF THE FOOT.

PLATE CCCXVIII.


Calcanean branches
External (lateral) plantar a.
Internal (medial) plantar n.
Internal (medial) plantar a.
External (lateral) plantar n.
Flexor accessorius (quadratus plantae) m.
Flexor digitorum longus m.
Superficial digital branch of internal (medial) plantar a.
Flexor digiti quinti brevis m.
Flexor hallucis longus m.
Abductor hallucis m.
Abductor digiti quinti m.
Lumbricales muscles
Collateral digital a.
Tendons of flexor digitorum brevis m.

SECOND LAYER OF MUSCLES OF THE SOLE OF THE FOOT, PLANTAR VESSELS AND NERVES.

and from the intermuscular septum between it and the flexor digitorum brevis. The *medial head arises* from the internal annular ligament (*ligamentum laciniatum*), and from the tendinous insertion of the tibialis posterior muscle. Between these two heads, and under the arch formed by their junction, pass the posterior tibial vessels. Its fibers terminate in a tendon which, with the most medial tendon of the flexor hallucis brevis, is *inserted* into the medial side of the base of the proximal phalanx of the great toe.

Nerve Supply.—From the internal (*medial*) plantar nerve.

Action.—To abduct and flex the great toe.

The **abductor digiti quinti muscle** lies along the lateral side of the foot and *arises* by a very strong and broad origin from the lateral tuberosity on the under surface of the os calcis (*calcaneus*), from the plantar fascia, and from the lateral intermuscular septum between it and the flexor digitorum brevis. Its fibers terminate in a tendon which, with the tendon of the flexor digiti quinti brevis, is *inserted* into the lateral side of the base of the proximal phalanx of the little toe.

Nerve Supply.—From the external (*lateral*) plantar nerves.

Action.—To abduct and flex the fifth toe.

Dissection.—Divide the superficial muscles at their origin and reflect them downward. This will bring into view the plantar vessels and nerves, the tendons of the flexor digitorum longus, the flexor hallucis longus, the flexor accessorius (*quadratus plantæ*), the lumbricales, the flexor hallucis brevis, the flexor digiti quinti brevis, the long plantar ligament, the terminal portion of the tendons of the tibialis anterior and tibialis posterior, and a portion of the peroneus longus. (Plate CCCXVIII.)

The **posterior tibial artery** enters the sole of the foot between the two heads of origin of the abductor hallucis muscle and divides beneath the os calcis (*calcaneus*) into its two terminal branches, the external (*lateral*) and internal (*medial*) plantar arteries.

The **external (lateral) plantar artery,** the larger of the two, is the principal artery of the sole of the foot. Together with the communicating branch of the dorsalis pedis it forms the plantar arch. It passes obliquely laterally and forward to the base of the metatarsal bone of the little toe accompanied by the external (*lateral*) plantar nerve, and rests upon the plantar surface of the flexor accessorius (*quadratus plantæ*) muscle. At the anterior part of the foot it turns and runs obliquely toward the medial side, under cover of the flexor tendons, across the bases of the four lateral metatarsal bones to the interval between the base of the metatarsal bones of the great and second toes, where it anastomoses with the communicating branch from the dorsalis pedis artery, thus completing

the formation of the **plantar arch.** In the first half of its course, that is, from the medial aspect of the os calcis (*calcaneus*) to the base of the metatarsal bone of the little toe, the artery is placed beneath the abductor hallucis and then beneath the flexor digitorm brevis and the flexor accessorius (*quadratus plantæ*) and laterally between the flexor digitorum brevis and the abductor digiti quinti muscles. In the latter situation it is most superficial, being covered only by the skin and by superficial and deep fascia. In the last half of its course it lies deep, and will be examined after the dissection of the third layer of the muscles. It is accompanied by its venæ comites and the external (*lateral*) plantar nerve.

The branches of the external (*lateral*) plantar artery are: the muscular, cutaneous, calcanean, anastomotic, articular, posterior perforating, and digital.

The *muscular branches* are given off to the adjacent muscles throughout the course of the artery.

The *cutaneous branches* pass between the middle and lateral portions of the plantar fascia, to supply the skin on the lateral side of the foot.

The *calcanean branches* run over the medial surface of the os calcis (*calcaneus*) and anastomose with branches of the internal (*medial*) calcanean branch of the posterior tibial artery.

The *anastomotic branches* anastomose with the tarsal and metatarsal branches of the dorsalis pedis artery over the lateral surface of the foot.

The *articular branches* are given off from the deep plantar arch opposite the digitals, and supply the tarsal joints. They are usually three in number.

The *posterior perforating branches*, three in number, communicate, through the second, third, and fourth spaces, between the heads of the corresponding dorsal interosseous muscles, with the first, second, and third interosseous (*metatarsal*) arteries.

The *digital branches*, usually four in number, are named, in the order in which they are given off, from lateral to medial; fifth, fourth, third and second.

The fifth, or most lateral, digital artery runs along the lateral side of the foot and little toe; the medial digitals pass along the interosseous spaces and between the primary divisions of the central portion of the plantar fascia to reach the clefts of the toes, where each divides into two branches for the supply of the adjacent sides of the toes. The medial side of the second and both sides of the first toe are supplied by the princeps hallucis (*first plantar metatarsal*) artery, which is given off at the point of junction of the external (*lateral*) plantar with the communicating branch of the dorsalis pedis artery. This vessel, immediately after its origin, divides into two branches, the medial one supplying the medial

side of the great toe, and the lateral one passing over the interosseous space to the web between the great and second toes, where it divides into two branches for the supply of the adjacent sides of the first and second toes. At the bifurcation each digital artery gives off a branch which ascends through the forepart of the interosseous space, anastomosing with the interosseous branches of the metatarsal artery. These vessels are known as the *anterior perforating arteries*. The four lateral digital branches of the arch resemble the digital branches of the superficial palmar arch. The digital branch to the great toe, or first digital, would represent the princeps pollicis and the radialis indicis arteries.

The **internal (medial) plantar artery,** the remaining terminal division of the posterior tibial, is very much smaller than the external (*lateral*) plantar. It passes forward between the flexor digitorium brevis and the abductor hallucis muscles to the base of the great toe, being overlapped by the latter muscle in the first portion of its course. It then passes along the medial side of the great toe, much diminished in size, and anastomoses with the digital arteries, derived from the princeps hallucis (*first plantar metatarsal*) artery. It is accompanied by its venæ comites and the internal (*medial*) plantar nerve.

The branches of the internal (*medial*) plantar artery are the muscular, cutaneous, articular, anastomotic, and superficial digital; they are small and rather irregular in their origin and distribution.

The **posterior tibial (tibial) nerve,** like the posterior tibial artery, enters the sole of the foot under the origin of the abductor hallucis muscle and divides into its two terminal divisions: the internal (*medial*) and external (*lateral*) plantar. Before it enters the sole of the foot it gives off a few branches to the ankle-joint, and the internal (*medial*) calcanean, or calcaneo-plantar, cutaneous branch, which pierces the internal lateral (*deltoid*) ligament and supplies the skin and fascia over the heel. It is mentioned at p. 797.

The **external (lateral) plantar nerve** is the smaller of the two, and accompanies the external (*lateral*) plantar artery in the first half of its course, thus having the same relations as the artery. When it reaches the interval between the flexor accessorius (*quadratus plantæ*) and the abductor digiti quinti, it divides into a superficial and a deep branch. The *superficial branch* breaks up into two digital branches. The smaller of the two communicates with the lateral digital branch of the internal (*medial*) plantar nerve and supplies the flexor digiti quinti brevis and the plantar and dorsal interossei of the fourth space and the contiguous sides of the third and fourth and the fourth and fifth toes. The other, the larger, digital branch supplies the lateral side of the little toe. The *deep branch* accompanies the external (*lateral*) plantar artery in the deep part of the sole of the foot, and supplies the three lateral lumbricales muscles, the interosseous muscles in

the three medial spaces, the transverse and oblique heads of the abductor hallucis muscle.

The **internal (medial) plantar nerve** is the larger of the two terminal divisions of the posterior tibial nerve. It accompanies the internal (*medial*) plantar artery along the medial side of the foot, running between the abductor hallucis and the flexor digitorum brevis. It gives cutaneous branches to the skin of the sole, muscular branches to the muscles beneath which it runs, and articular branches to the tarsal and metatarsal joints. Opposite the bases of the metarsal bones it divides into four digital (*common plantar digital*) branches which pass between the primary divisions of the plantar fascia, accompanying the digital arteries. They are distributed in the following manner: the lateral three digitals at the clefts of the toes divide, each into two branches, the proper digital branches, for the supply of the adjacent sides of the third and fourth toes, the adjacent sides of the second and third toes, and the adjacent sides of the second and great toes; the most medial digital nerve passes along the medial side of the foot to supply the medial side of the great toe, and sends a branch to the flexor hallucis brevis muscle; the second digital nerve sends a filament to the first lumbrical muscle, the third digital gives off a filament to the first lumbrical muscle, and the fourth digital communicates with the external (*lateral*) plantar nerve, with which it then supplies the adjacent surfaces of the third and fourth toes. All the digital nerves give off branches to the integument, to the matrix of the nail, and to the phalangeal joints. The internal (*medial*) plantar nerve supplies the same region in the sole of the foot that the median nerve does in the palm of the hand.

The second layer of muscles comprises the flexor accessorius digitorum pedis (*quadratus plantæ*), the tendon of the flexor digitorum longus, to which the former is attached, the tendon of the flexor hallucis longus, and the lumbricales muscles.

The **flexor accessorius digitorum pedis (quadratus plantæ)** arises by two heads. The lateral, tendinous head *arises* from the under surfaces of the os calcis (*calcaneus*) and the long plantar ligament; the large and muscular medial head *arises* from the medial surface of the os calcis (*calcaneus*) and from the calcaneo-scaphoid (*calcaneo-navicular*) ligament. The two portions unite in an acute angle to form the belly of the muscle which is *inserted* into the lateral side of the upper surface of the tendon of the flexor digitorum longus. The plantar surface of the flexor accessorius (*quadratus plantæ*) is in contact with the flexor digitorum brevis and with the external (*lateral*) plantar vessels and nerve; the dorsal surface is in relation with the os calcis (*calcaneus*) and with the long calcaneo-cuboid ligament.

Nerve Supply.—From the external (*lateral*) plantar nerve.

Action.—Its action is to assist the flexor digitorum longus in flexing the toes plantarward.

The **tendon of the flexor digitorum longus** enters the sole of the foot by passing over the internal lateral (*deltoid*) ligament of the ankle-joint, and beneath the internal annular ligament (*ligamentum laciniatum*). In the sole of the foot it passes over the tendon of the flexor hallucis longus, to which it is connected by a tendinous slip, beyond which it is joined by the flexor accessorius (*quadratus plantæ*). It divides into four tendons, each of which enters the theca of the toe with the tendon of the flexor digitorum brevis, but dorsally to it. Opposite the middle of the proximal phalanges of the four lateral toes, the tendons pass through the slit-like openings in the tendons of the flexor digitorum brevis. They are *inserted* into the base of the terminal phalanges. The tendons of the flexor digitorum longus give origin to the lumbricales muscles.

Nerve Supply.—From the posterior tibial (*tibial*) nerve.

Action.—Its action is to plantar flex the four lateral toes and to extend the ankle (plantar flexion).

The **lumbricales** are four small muscles placed between, and arising from the tendons of the long flexor. Each *arises* by two heads from the adjacent sides of the tendons, with the exception of the most medial, which *arises* from the medial side of the tendon which goes to the second toe. Each muscle terminates in an aponeurosis which passes round the medial surface of the proximal phalanges of the four toes, and is *inserted* into the expansion of the tendon of the extensor digitorum longus, and into the dorsal aspect of the base of the proximal phalanges of the corresponding toes.

Nerve Supply.—The medial lumbrical muscle is supplied by the internal (*medial*) plantar, and the three lateral by the external (*lateral*) plantar nerve.

Action.—The action of these muscles is to assist the flexors in bending the metatarso-phalangeal joints of the four lesser toes, and, by their attachment to the tendons of the extensor digitorum longus, they assist that muscle in straightening the toes.

The **tendon of the flexor hallucis longus** enters the sole of the foot between the heads of the flexor hallucis brevis. It runs over the plantar surface of the latter, enters the digital sheath, and is *inserted* into the base of the second phalanx of the great toe.

Nerve Supply.—See description of the muscle at page 798.

Action.—The action of this tendon is to flex the great toe and to assist in extending the foot.

Dissection.—To make a dissection of the remaining tissues in the sole of the foot, it will be necessary to cut the tendon of the flexor digitorum longus,

the flexor accessorius (*quadratus plantæ*), and the plantar vessels and nerves near the os calcis (*calcaneus*).

By displacing the severed structures downward, the third layer of muscles, the flexor hallucis brevis, the adductor obliquus hallucis (*oblique head of adductor hallucis*), the flexor digiti quinti brevis, and the transversus pedis (*transverse head of adductor hallucis*) muscles will be brought into view. The long plantar ligament, the sheath of the peroneus longus, and the interossei muscles will also be exposed. (Plate CCCXIX.)

The **flexor hallucis brevis** *arises* by a pointed tendon from the medial portion of the under surface of the cuboid bone, from the lateral (*second and third*) cuneiform bones, and from the prolongation of the tendon of the tibialis posterror. It passes along the metatarsal bone of the great toe to reach a point near the head of the bone. Here it divides into two portions which are *inserted* into the sides of the proximal phalanx of the great toe, the medial being associated with the abductor hallucis, and the lateral with the tendon of the adductor hallucis. In each of these portions there is a sesamoid bone.

Nerve Supply.—From the internal (*medial*) plantar nerve.

Action.—Its action is to flex the metatarso-phalangeal joint of the great toe. In very pronounced forms of talipes varus the tendon of insertion of this muscle will often call for division, as severing of the plantar fascia alone will not correct the deformity.

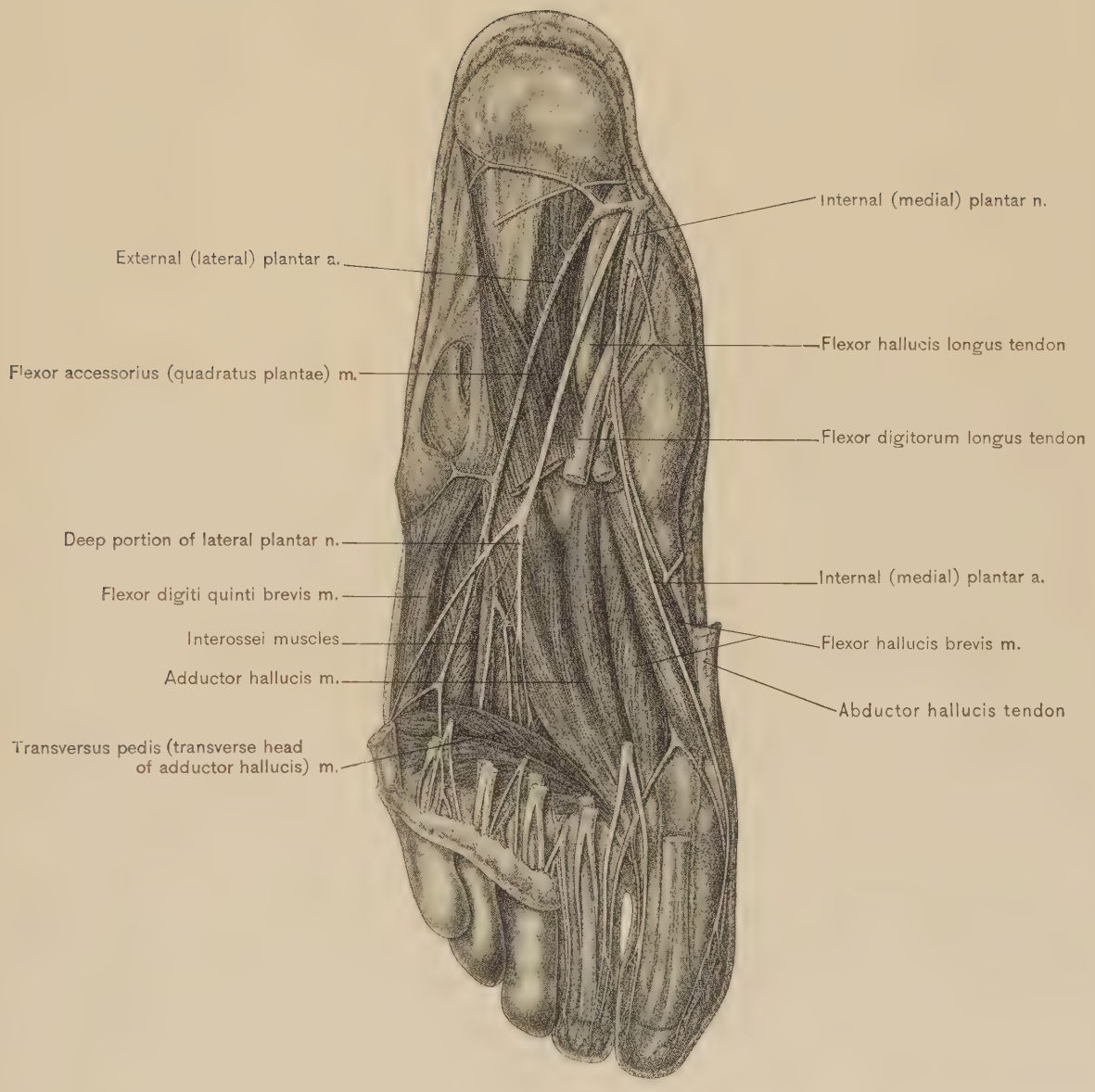
The **adductor hallucis** is a very strong muscle, and is larger than the flexor hallucis brevis. It consists of two parts, the oblique head and the transverse head (*transversus pedis*). The oblique head *arises* from the bases of the second, third, and fourth metatarsal bones and from the long plantar ligament, which forms the sheath of the peroneus longus. Its fibers pass forward and medialward and terminate in a tendon which is *inserted* into the lateral border of the base of the proximal phalanx of the great toe in connection with the lateral head of the flexor hallucis brevis. The transverse head *arises* from the capsular ligaments of the lateral four metatarso-phalangeal articulations and the plantar surface of the transverse metatarsal ligament. It runs medially beneath the flexor tendons and lumbricales to be *inserted* with the oblique head into the lateral side of the base of the proximal phalanx of the great toe.

Nerve Supply.—It receives its nerve supply from the external (*lateral*) plantar nerve.

Action.—Its action is to draw the great toe toward the others and to assist in flexing the metatarso-phalangeal joint of this toe.

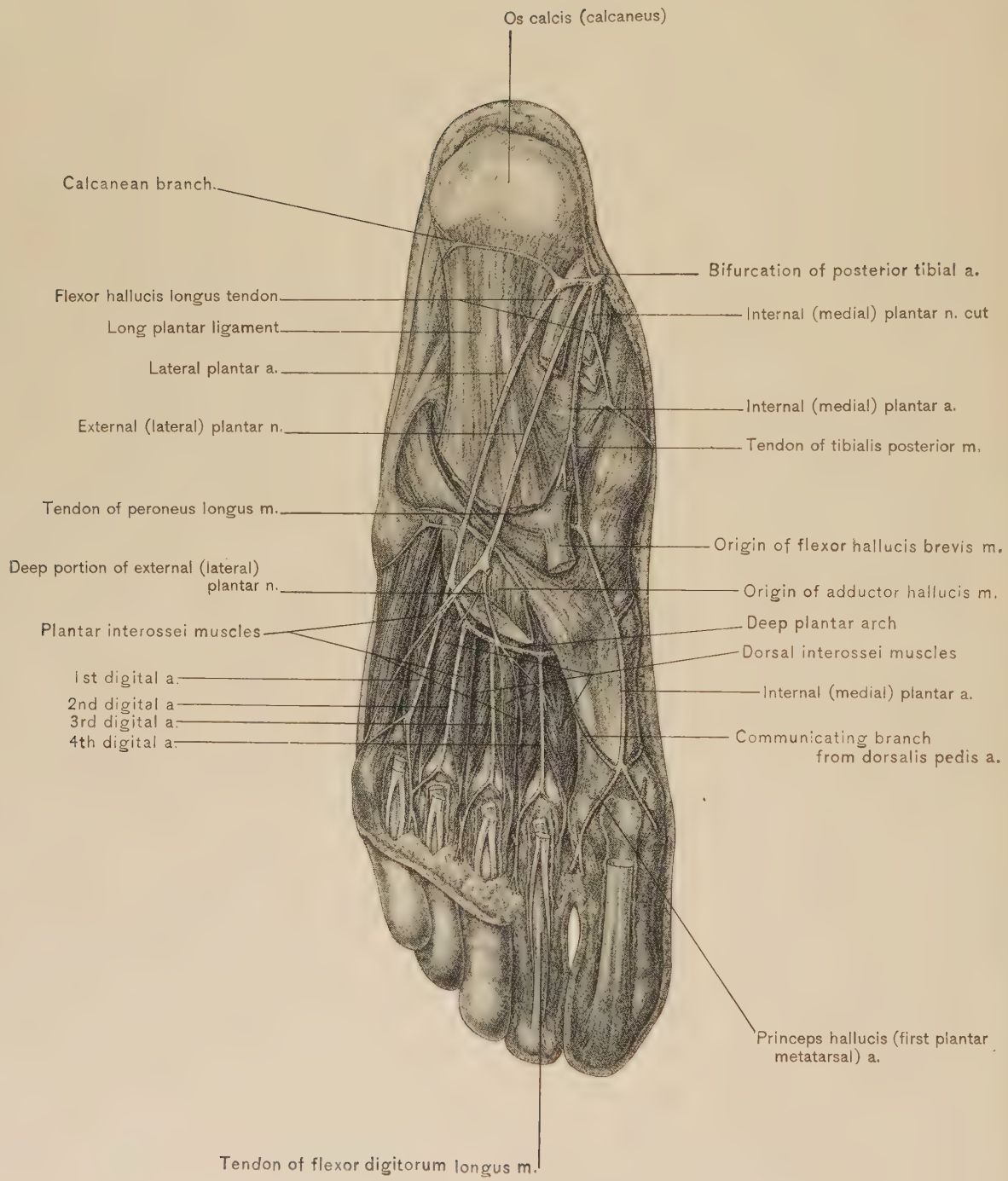
The **flexor digiti quinti brevis,** a small muscle, is situated along the lateral aspect of the foot. It *arises* from the base of the fifth metatarsal bone and from

PLATE CCCXIX.


Internal (medial) plantar n.
External (lateral) plantar a.
Flexor hallucis longus tendon
Flexor accessorius (quadratus plantae) m.
Flexor digitorum longus tendon
Deep portion of lateral plantar n.
Internal (medial) plantar a.
Flexor digiti quinti brevis m.
Interossei muscles
Flexor hallucis brevis m.
Adductor hallucis m.
Abductor hallucis tendon
Transversus pedis (transverse head of adductor hallucis) m.

THIRD LAYER OF MUSCLES OF THE SOLE OF THE FOOT.

PLATE CCCXX.


Os calcis (calcaneus)
Calcanean branch
Bifurcation of posterior tibial a.
Flexor hallucis longus tendon
Internal (medial) plantar n. cut
Long plantar ligament
Lateral plantar a.
Internal (medial) plantar a.
External (lateral) plantar n.
Tendon of tibialis posterior m.
Tendon of peroneus longus m.
Origin of flexor hallucis brevis m.
Deep portion of external (lateral) plantar n.
Origin of adductor hallucis m.
Plantar interossei muscles
Deep plantar arch
Dorsal interossei muscles
1st digital a.
Internal (medial) plantar a.
2nd digital a.
3rd digital a.
4th digital a.
Communicating branch from dorsalis pedis a.
Princeps hallucis (first plantar metatarsal) a.
Tendon of flexor digitorum longus m.

FOURTH LAYER OF MUSCLES OF THE SOLE OF THE FOOT, PLANTAR ARCH, AND DEEP BRANCH OF THE EXTERNAL (LATERAL) PLANTAR NERVE.

the fibrous sheath of the peroneus longus. Its fibers pass forward and terminate in a tendon which is *inserted* into the lateral side of the base of the proximal phalanx of the little toe and the adjacent part of the fifth metatarsal bone.

Nerve Supply.—From the external (*lateral*) plantar nerve.

Action.—Its action is to plantar flex the little toe and to assist in adducting it.

Dissection.—The flexor hallucis brevis and the adductor hallucis should be severed at their origin and reflected, when will be brought into view the plantar arch and its branches, the communicating branch of the external (*lateral*) plantar nerve, and the terminal part of the communicating branch of the dorsalis pedis artery, which enters the sole of the foot through the first interosseous space. (Plate CCCXX.)

The Plantar Arch.—The formation of the plantar arch has already been given. It is the continuation of the external (*lateral*) plantar artery. It runs across the bases of the metatarsal bones resting upon the interossei muscles. It is covered by the flexor tendons, the lumbricales, the oblique portion of the adductor hallucis, and a part of the flexor hallucis brevis. From the arch are given off the articular, posterior perforating, and four digital arteries for the supply of the three lateral toes and the lateral surface of the second toe. These have already been described.

The *deep branch of the external* (*lateral*) *plantar nerve* accompanies the plantar arch on its concave or posterior aspect and ends in the oblique head of the adductor hallucis muscle. It supplies the three medial interossei, the transverse head of the adductor hallucis, and the second, third and fourth lumbricales muscles. This nerve corresponds to the deep branch of the ulnar nerve in the palm of the hand.

Dissection.—Displace the digital vessels and nerves downward, and study the interossei muscles. Reflect the transverse head of the adductor hallucis and the flexor digiti quinti brevis from their origin. The strong band of fibrous tissue connecting the heads of the metatarsal bones (the transverse metatarsal ligament) and the interossei muscles are now exposed. These muscles are covered with a thin layer of fascia attached to the transverse metatarsal ligaments; this should be removed and the ligaments cut between the bones.

The interossei muscles constitute the fourth layer of muscles. They are seven in number, four dorsal and three plantar.

The **plantar interossei** are situated beneath the third, fourth, and fifth metatarsal bones, from the plantar and medial surfaces of which they arise. They are *inserted* into the medial border of the bases of the proximal phalanges of the corresponding toes, and partly by an expansion to the extensor tendons

on the back of the phalanges. These muscles are smaller than the dorsal interossei.

The **dorsal interossei** are situated in the metatarsal spaces. They *arise* by two heads from the sides of the adjacent metatarsal bones and are *inserted* into the bases of the proximal phalanges, and into the aponeurosis of the extensor tendons upon the dorsum of the toes. The first is *inserted* into the medial surface of the second toe, and the remaining three into the lateral surface of the second, third, and fourth toes. The first dorsal interosseous of the foot, like its homologue in the hand, has an artery passing between its two heads. In the foot the vessel is the communicating branch of the dorsalis pedis, while in the hand the radial artery passes between the two heads of the first dorsal interosseous to form the greater part of the deep palmar (*deep volar*) arch.

Between the tendons of the interossei at the heads of the metatarsal bones are bursæ which facilitate movement; these may become inflamed, and cause painful swellings between the roots of the toes.

Nerve Supply.—The interossei muscles are supplied by branches of the external (*lateral*) plantar nerve.

Action.—The action of the interossei is to assist the flexor tendons in flexing the metatarso-phalangeal joints, and the extensors in straightening the distal two phalangeal joints. In this they are aided by the lumbricales. The plantar interossei also adduct the third, fourth, and fifth toes toward the second toe. The third and fourth dorsal interossei abduct the third and fourth toes from the second. The first and second dorsal interossei alternately abduct and adduct the second toe. Each toe therefore has an abductor and adductor. The hallux has its special abductor and adductor; the second, third, and fourth toes each have two interossei, and the fifth toe has its special abductor and the third plantar interosseous has its adductor.

The **tendon of the tibialis posterior** passes forward over the internal lateral (*deltoid*) ligament of the ankle-joint and over the capsular ligament of the astragalo-scaphoid (*talo-navicular*) articulation, and at the latter point contains a sesamoid bone. It is *inserted* into the tuberosity of the scaphoid (*navicular*) bone. From its insertion, prolongations are continued to all the tarsal bones except the astragalus (*talus*), and to the bases of the metatarsal bones with the exception of the medial and lateral ones. From the manner in which the tendon is inserted it must assist largely in the maintenance of the arch of the foot.

The **tendon of the peroneus longus,** the deepest muscle in the sole, is confined by a strong fibrous sheath which is lined throughout by a synovial membrane. The sheath should be laid open, when the tendon will be seen to run through a groove on the under surface of the cuboid bone, then obliquely across

the sole. At the point where it enters the groove in the cuboid bone, it contains a fibrocartilaginous nodule which may become a sesamoid bone. The tendon *inserted* into the lateral side of the base of the first metatarsal bone and into the internal (*first*) cuneiform bone; sometimes it has a slip of attachment to the base of the second metatarsal bone.

NOTE: The joints of the lower extremities, dislocations, and amputations, will be discussed in Volume III.

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